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The Tri-Met Quiet Transit Bus Project
A Case Study

ORI, Inc.
Silver Spring, MD

Prepared for

Environmental Protection Agency
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16. Abstract

This report details the cooperative activities of a number of agencies at the Federal, State and local levels both to improve downtown transit-bus service and to reduce the noise associated with that service.

Starting from a baseline of 80 dBA a reduction of about 4 dBA has been achieved, and the reduction involved only the use of "operationally acceptable" noise treatments. Additional quieting seems attainable with application of advanced technology concepts. "Operationally acceptable" in the context of this study means noise treatments that the management of Tri-Met accepted as not having a detrimental effect on maintenance. For those Portland buses that had 80 dBA noise levels initially, the operationally acceptable noise treatment will give a reduced noise level of 76 dBA.

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THE TRI-MET QUIET TRANSIT BUS PROJECT
A CASE HISTORY

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FOREWORD

This report was prepared by ORI, Inc. in response to Task Order 15, Contract No. 68-91-5040. The task order required a report that describes the history of the development, testing, and evaluation activities that constituted the Tri-Met Bus Noise Reduction Retrofit Program, the aim of which was to reduce bus noise emissions. The relationship of this program to the development of the Portland Transit Mall was also to be described. The history was to be fully documented and suitable for distribution by the Office of Noise Abatement and Control of the Environmental Protection Agency and the Urban Mass Transit Administration for information and assistance to others concerned with the reduction of transit bus noise.

The author wishes to thank Harvey J. Nozick and Eugene F. Wyszpolski, EPA Technical Monitors, for guidance and constructive comments on drafts of this report.

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THE TRI-MET QUIET TRANSIT BUS PROJECT
A CASE HISTORY

SUMMARY

This report details the cooperative activities of a number of agencies at the Federal, State and local levels both to improve downtown transit-bus service and to reduce the noise associated with that service.

The City of Portland and its bus-operating authority, Tri-Met, wanted to improve traffic flow in downtown Portland. To do this they developed the concept of a downtown "transit mall," served almost exclusively by buses. The Urban Mass Transportation Administration (UMTA) agreed to support the expense of building the mall on a cost-sharing basis. Concern with the noise environment arose when it was realized that noise levels along the mall were high enough to violate U.S. Department of Housing and Urban Development (HUD) noise-level standards. Reinforcing the impetus provided by the Federal agencies, a State agency, the Oregon Department of Environmental Quality (DEQ), felt that operating quieter buses on the mall would improve the quality of life.

Responding to these pressures and needs, the U. S. Environmental Protection Agency (EPA) obtained support to investigate the possibility of quieting the buses in their operating fleet. A grant, jointly funded by EPA

and UMTA, in the amount of $165,000 was made to Tri-Met in April 1978. In July 1978 a consulting acoustical engineer was hired by Tri-Met to begin work on quieting buses.

Starting from a baseline of 80 dBA a reduction of about 4 dBA has been achieved, and the reduction involved only the use of "operationally acceptable" noise treatments. Additional quieting seems attainable with application of advanced technology concepts. "Operationally acceptable" in the context of this study means noise treatments that the management of Tri-Met accepted as not having a detrimental effect on maintenance. For those Portland buses that had 80 dBA noise levels initially, the operationally acceptable noise treatment will give a reduced noise level of 76 dBA.

Three appendices are provided at the end of this report. Appendix A gives the details of HUD's noise criteria for urban areas. Appendix B reviews the process for obtaining procurement and modification grants from UMTA. Appendix C is a service bulletin prepared by Tri-Met documenting the treatments and procedures to be followed to permit other transit agencies to emulate this noise-abatement action.

HISTORY OF THE PORTLAND, OREGON TRANSIT MALL

TRI-MET, the Tri-County Metropolitan Transportation District of Oregon, is the public transit authority providing major transit service in the Portland, Oregon metropolitan area. As a public transit service, TRI-MET has the public-interest goal of increasing public use of its services, which will lead to reduced congestion, decreased air pollution, and increased energy conservation; at the same time increased use of the service will help to stabilize the downtown business district of Portland.

Part of the overall program of increasing use of an improved public transit system is the concept of developing a downtown transit mall that would be served almost exclusively by buses--only limited access by automobiles and trucks being permitted. The transit mall was conceived by a Downtown Committee, formed in 1970 and consisting of business people and property owners who wanted to stimulate planning to revitalize downtown Portland.

The following material, which gives the Portland transit mall history, is drawn in considerable measure from a report by David Koffman and Richard Adminster of Crain Associates, Menlo Park, California.[1]

The earliest transit mall proposal involved no construction but merely elimination of parking on the left side of the street to leave room on the existing roadway for two exclusive bus lanes and two lanes for general traffic. The concept had inadequacies, including insufficient waiting space on sidewalks and conflicts between bus and auto traffic. Discussions involving the Downtown Plan Staff, the Bureau of Traffic Engineering, and consultants led to the conclusion that the project should extend to widened, landscaped sidewalks and provision for eventual removal of general traffic. The initial configuration, however, would have had two general traffic lanes, and 10-foot bus lanes.

The mall concept was approved by the City Planning Commission in 1971 and by the City Council in 1972. A preliminary design study was completed under an UMTA grant, and the City Council approved one of the alternatives examined. The alternative adopted utilized three lanes for traffic; the right lane was reserved for buses, the left for automobiles, and both could use the center lane. As bus volume increased, it was planned to change the center lane, and then all three lanes, to exclusive transit use. The initial configuration was a response to downtown business interests that opposed the immediate elimination of automobile access on the mall or the construction of wider sidewalks in some blocks, since that would make the restoration of the third lane to automobile use difficult.

The preliminary design study also discussed the purpose of the mall, which is primarily to improve transit service. This is also a major objective of planning in the Portland area. The objectives of improved transit service, concentration of development in the downtown core near the mall, and reduction of air pollution are all seen as mutually supporting and served by the mall. The mall's purpose was further discussed in an Environmental Impact Statement (EIS), which mentioned that the mall was intended to:

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[1] Streets for Pedestrians and Transit: A site Report on Transit Malls in the United States, Final Report, DOT-TSC-1091-19 August 1977; Cambridge, Mass.

1. Minimize conflicts between auto, bus, and pedestrian traffic while providing efficient transportation for shoppers and commuters into the CBD;
2. Make bus travel as efficient and convenient as possible because mass transportation promotes better land use, consumes less energy, and produces less pollution than automobile travel;
3. Encourage bus travel while discouraging travel by automobile;
4. Make bus travel faster;
5. Make transfers easier;
6. Make the route system more comprehensible;
7. Provide an environment inviting to residents and visitors, thereby benefiting downtown businesses and making the downtown more competitive with suburban locations.

Tri-Met made a preliminary grant application to UMTA in September 1973 for financial aid in engineering and building the mall. UMTA refused to fund the project fully with the existing design. UMTA's refusal was based on the mixed-use center lane and the degree to which private vehicles would have access to the mall. The final grant application, submitted in April 1974, presented the final design, which reduced the number of lanes from three to two and restricted their use to buses. Approval of the engineering portion of the grant application was received quickly. In June 1975, a draft EIS was published. The EIS included a summary analysis of several alternatives and presented the major expected changes in traffic patterns. The analysis concentrated on predicting air- and noise-pollution impacts, since many people were concerned that the anticipated bus traffic would make the mall an unpleasant place for pedestrians. Increases in noise levels and nitrogen oxides and decreases in levels of carbon monoxide, hydrocarbons, and particulates in the mall area were predicted. On the nearby streets, increases in air pollution due to diverted traffic were expected.

Approval was received February 1976 for 80-percent funding of all costs except for $1 to $1.5 million in utilities work. Work on the mall began in the spring of 1976, and opening ceremonies took place March 20-24, 1978. The final cost of the mall was approximately $16 million.

The current status of the mall is this: General traffic has been excluded on two adjacent thoroughfares in the 22 blocks of the mall area ever since construction began. The planned route consolidation and relocation has been put in effect. Peak scheduled two-way bus traffic on the mall is about 260 buses per hour in both the morning and evening peak periods. Despite the heavy volumes, Tri-Met operations personnel are satisfied that things are going smoothly and that bus travel times have been significantly reduced. Before the mall, at peak-hour, buses required over 15 minutes, on the average, to negotiate a distance now covered in 8 to 10 minutes. Some routes, however, have lost time overall due to having been rerouted.

Parking had been removed from two other thoroughfares to handle the expected increase in traffic. However, since no problems appeared, parking has since been reallowed without detrimental effect. Apparently, reductions in buses and in turning and circulating traffic on these streets have compensated for any diverted traffic.

The mall is now a very attractive feature of downtown Portland. The wide brick pedestraian walkways are lined with trees, plantings, sculpture , sheltered benches, and attractive route displays. Related improvements in the traffic routing and a "Fareless Square" within the downtown area, where riders can ride at no charge, have all contributed to increased accessibility to the downtown area.

The rebirth of activity along the transit mall has stimulated new construction. Several new office buildings have been completed. There has also been a major commitment to new development by private retailers. New department stores have come to the downtown area, and other stores have improved or expanded existing facilities.

ROLE OF THE DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT (HUD)

The Portland city planners, finding themselves well on the way to relieving downtown traffic congestion and attracting customers for downtown shopping through operation of the transit mall, also wanted to improve housing in downtown Portland. As one of its first steps, the city took over a downtown YMCA building with the intention of converting it to housing for the elderly. They sought financial support from HUD to do this but found that HUD's noise pollution requirements did not permit support. (In the previous months about half of the "Section-8" housing sites prepared for downtown area redevelopment were rejected by HUD, primarily because of noise. This was one of the factors that convinced city planners of the need to alleviate downtown transit noise.) Failing to get HUD funding, the city permitted the YMCA building to be torn down. There was an unofficial hold on housing subsidies for renovation until bus quieting could be achieved. It was concluded that new construction along the mall would have to be commercial because there would continue to be too much noise for residential properties.

HUD's policy on noise control, in effect at the time the mall was being developed, is described in "Department Of Housing and Urban Development: Noise Abatement and Control Policy."[1]

HUD's noise-control policy is predominantly a land-use policy. It states that HUD assistance in supporting property-development projects requires consideration of the noise environment. The policy applies to new construction or "substantial rehabilitation," and the current policy is described in "Environmental Criteria and Standards" (See Appendix A for the complete text).[1] Site acceptability standards are provided in this document (See p. 40864, Appendix A).

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[1] "Department of Housing and Urban Development: Noise Abatement and Control Policy," EPA, Office of Noise Abatement and Control, EPA 550/9-77-354, April 1977.

BUS QUIETING BECOMES AN ISSUE

A survey of noise conditions before construction of the transit mall began indicated that there was a noise level, L_{dn}, of 75 dBA[2]. On opening day when 1380 buses used the mall, the noise level became L_{dn}= 76 dBA. It was then predicted that by 1980, with 1900 buses using the mall, L_{dn} would equal 77 dBA and by 1990, with 3000 buses, there would be an L_{dn} of 78 dBA. Since the HUD requires 65 dBA, there would be great difficulty in getting HUD support for downtown renewal.

The Oregon Department of Environmental Quality (DEQ) reported a modeling study that led to the conclusion that Tri-Met would have to operate a fleet of 77 dBA buses on the Portland mall to comply even with the least-stringent standard (EPA's hearing-loss guide). Compliance with the HUD standard would have required acquisition of a fleet of 72 dBA buses. By way of comparison it should be noted that Tri-Met's quietest buses had noise emission levels of 80 to 83 dBA, which means that the quietest buses would have to be quieted 3 to 6 dBA to meet the least stringent guide. A 65 dBA bus fleet would be necessary to meet the most stringent guide (EPA's annoyance level guide). This had never been seriously considered as an achievable objective. Indeed, the L_{dn} = 55 dBA ambient standard is viewed in Portland as more of a long-term goal than an achievable standard.

In order to move toward effective bus quieting in Portland a staff-level Noise Working Group consisting of Tri-Met, City of Portland, HUD, and DEQ representatives was formed. Planning meetings began over a year before mall construction was completed. Noise and air pollution, including odor from bus operations, were identified as the major concerns. Quarterly progress was slow in researching these problems and in gaining commitments to solve them. Tri-Met's Environmental Impact Statement for the mall worried DEQ, because it indicated that Tri-Met might be underestimating the magnitude and/or importance of bus noise, especially as the mall became fully operational.

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[1] Federal Register, Part V, pp. 40860-6, Department of Housing and Urban Development, Office of the Secretary, Environmental Criteria and Standards, July 12, 1979.

[2] L_{dn}, day-night sound level, is the energy-averaged equivalent level (L_{eq}) for 24 hours, adjusted to include a 10 dB penalty for noise exposures during night-time hours (10 p.m. to 7 a.m.).

Consequently, ambient noise standards were proposed for the mall to become part of Oregon law. They would be the first of their kind under Oregon law, being specific as to affected location (transit malls) and primarily affecting one class of vehicle sources (transit buses). Tri-Met was concerned, because the proposed standards called for making the mall quieter than it had been prior to construction. This meant that Tri-Met would have to quiet its bus fleet considerably.

The DEQ's view as to what was needed to be done regarding noise abatement in the mall were presented in a white paper, Proposed Noise Standards for Transit Malls, dated June 30, 1976. Much of the DEQ's viewpoint regarding quiet on the mall is exemplified by the following quotation:

> Some people will work full time in the mall area and many others will congregate there to wait for buses. The mall will be a social space where people are encouraged to linger in social activities. A direct result will be increased public exposure to increasing noise levels which can adversely affect public health.

In reviewing the DEQ white paper, the General Manager of Tri-Met noted that:

> We feel that some of the problems between DEQ and Tri-Met lies in a misunderstanding about the basic purpose of the mall. It is not a park. It is a transit-device--in effect, an elongated bus station and transfer point. The mall was planned and approved...with this purpose known to everyone. The DEQ staff is in error in its assignment of other purposes to the mall.

Although Tri-Met did agree to work with DEQ and other interested parties, they were on record as opposing the use of certain measures of environmental noise which the DEQ used to make its case. If the DEQ saw the mall as a place for social activities, there would be greater concern for the impact of noise over long periods of time. If the primary outdoor exposure was to occasional pedestrians and bus passengers, more relaxed criteria designed for short-term exposure would be more appropriate. Nonetheless, Tri-Met agreed to do whatever was reasonable to reduce transit noise on the mall.

The Noise Working Group explored the state of the art of bus-noise-abatement technology and found that 80 to 86dBA buses were commercially available; a 77 dBA bus would not be easy to achieve (retrofit kits were not commercially available); and the 72 dBA bus looked like wishful thinking--at first!

A program sponsored by DOT with General Motors and Flxible demonstrated that bus noise could be significantly reduced through proper maintenance and insulation of the engine compartment including selective retrofit. Flxible submitted a proposal to Tri-Met in February 1977 to retrofit buses under Tri-Met's program with DOT.[1] The proposal was later withdrawn by Flxible.

During public meetings in response to a notice of proposed rule making, it was commented that regulation would not solve the noise problem of the Portland transit mall. Thus, Portland decided that it must take other measures to meet its needs. Members of the Noise Working Group and others persevered in their efforts to develop a program to solve their problems with bus noise by means of personal contacts and correspondence with HUD, UMTA, and EPA. Both General Motors and Flexible were asked to develop retrofit kits but both declined to do so. Since Tri-Met had a repair shop at its disposal, the group felt confident that a consultant could use the Tri-Met facilities to develop a retrofit kit for its own use.

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[1] Letter to Gerald Wood of Tri-Met from R.P. Diegnan of The Flxible Company, Tri-Met file number 1664, February 17, 1977.

As a result of the responsiveness and intiatives of EPA's Office of Noise Abatatement and Control (ONAC), Tri-Met obtained $165,000 from UMTA/EPA for a major study to determine how much quieter their existing transit buses could be made using retrofit technology (Phase I), and there were prospects for much larger funding to retrofit the entire fleet (Phase II) if substantial noise improvements resulted. Phase I is the major focus of this report. Phase I demonstrated the feasibility of obtaining 5 to 7 dBA noise reductions, which would quiet Tri-Met's present 80 to 83 dBA buses down into the 75 to 76 dBA range, using commercially available materials and reasonable maintenance procedures. These encouraging results have generated favorable local and national attention for Tri-Met, and represent a significant advancement in bus-noise-abatement technology. A study, funded by EPA and HUD, enabled the City of Portland to conduct its first systematic (though modest) survey of ambient noise levels downtown and along major transit corridor streets. The resulting data base is being used to determine the ambient noise levels in areas where the City has an interest in developing housing. A contractor, Wyle, Inc., has used the data base to prepare a model that predicts ambient noise levels at specific sites--such as a potential housing development site--based upon the traffic characteristics and adjacent building geometry. The model predicts noise levels at various distances from any city street, based upon traffic mix and volume, nearness and height of adjacent buildings, and other factors. The model is capable of estimating the effectiveness of a wide variety of noise-abatement strategies and is applicable to any community.

POSSIBLE SOLUTIONS TO THE BUS NOISE PROBLEM

At the time Portland officials became aware that bus noise was a problem that could possibly inhibit downtown redevelopment by exceeding HUD standards, the officials had several alternatives: Quiet the buses they had (retrofit), buy new quiet buses, or install other means of transportation. The second alternative could provide insufficient improvement, for no U.S. manufacturer was offering the 77 dBA buses that would be needed on the transit mall to achieve even the least stringent of the standards considered by the Oregon Department of Environmental Quality. The least-stringent standard is EPA's hearing loss guide, L_{eq} = 70 dBA. Portland's Noise Control Officer and others representing Portland argued in an EPA hearing on proposed bus-noise regulation that the EPA-proposed standards would take effect too late to benefit Portland. If the 77 dBA bus did not become commercially available until 1985 and a 15-year life for buses is assumed, it would be very close to the year 2000 before distinctly measurable fleet-noise reductions would appear in the Tri-Met bus fleet. The resulting fleet noise level would, of course, still be considerably above the HUD standard and the problems in obtaining HUD approval for downtown renovation would still be there.

To put matters in perspective, Tri-Met's engineering consultant pointed out that ambient noise along busy Portland neighborhood streets where bus routes are found would not be significantly lessened even if the Tri-Met buses made no noise at all. A study of three representative sites showed that statistical noise levels were controlled by other traffic noise and would not be reduced more than 2 dBA if all Tri-Met buses were completely silent. On the other hand, there would be a beneficial effect on the noise levels in relatively quiet neighborhoods served by bus routes. Also, annoyance to people close to passing buses would be reduced.

Overall it appeared to the Portland people that the U.S. manufacturers would not on their own produce sufficiently quiet buses to meet Portland's needs. Also, EPA was not likely, at least in the short-term, to achieve adequate bus quiet through the regulatory process. If Portland's needs for bus quieting were to be met, Portland would have to take matters into its own hands. Suported by the $165,000 grant from EPA and UMTA mentioned earlier, this is, in fact, what they undertook to do.

BUS QUIETING PROGRAM ADOPTED BY TRI-MET

General Objectives of the Program

Tri-Met's understanding of the purpose of the project could be summarized thus: to develop a noise-treated bus that would be both quiet and practical. As a result Tri-Met undertook to investigate as many new potential noise treatments as possible under the project budget of $165,000 provided jointly by EPA and UMTA (in response to a grant request submitted to UMTA on May 1978). The agreement between EPA and UMTA to support bus quieting in Portland was formally designated: Bus Retrofit Program, Interagency Agreement between Department of Transportation, Urban Mass Transportation Administration, Office of Bus and Paratransit Technology and the U.S. Environmental Protection Agency, Office of Noise Abatement and Control. The agreement specified that the program had two purposes:

1. To demonstrate that the DOT bus retrofit program can be applied to a fleet of properly maintained buses in use, and

2. To demonstrate noise-reduction results along a major bus route, including a transit mall, in a metropolitan area.

The program was to be run in two phases with funding initially only for Phase I. The Phase I effort was to design a noise kit and perform test and engineering evaluations of several kit installations. The Phase II effort, not yet funded, was, in the words of the agreement, intended to carry out an evaluation of a pre-production prototype transit operation, which would involve installation of the kit on different brands of buses. It would provide that:

a. Noise kit design definitions will be made to reduce noise level in a minimum of two-thirds of the selected bus fleet, and

b. sufficient noise configurations shall be installed to permit a major route service evaluation of noise with and without noise kits and transit mall noise level shall also be evaluated with and without noise kits.

In other words, Phase I was to show that significant bus quieting could be performed at reasonable cost, through design and installation of a few new noise kits. Phase II was to apply the kits throughout a major portion of the Tri-Met bus fleet.

Specific Objectives of the Program

The first meeting of the Technical Advisory Committe for Tri-Met's Bus Noise Reduction Project, held in the summer of 1978, achieved agreement on the following matters:

1. Two appropriate EPA noise-measurement test procedures were adopted.

2. Noise-measurement instrument needs were specified.

3. Performance-testing instrumentation was located to measure fuel and oil consumption, engine and cooling-system effectiveness, and vehicle performance while the noise-treated bus was in regular revenue service.

It was further agreed that the work of the engineering consultant would include:

1. Conducting baseline acoustical tests on the untreated buses using the EPA standard procedures that had been agreed on.

2. Conducting baseline performance tests on the untreated buses to include determination of:

    a. cooling-system capability

    b. engine aspiration--air intake and exhaust characteristics

    c. usable wheel horsepower

    d. fuel consumption.

3. Designing and installing the noise-reduction equipment to include:

a. abating engine mechanical noise by use of double-skinned, damped rocker-arm covers, a double-skinned, damped oil-pan cover, and damped exhaust-manifold covers

b. abating air-intake noise through use of turbocharging and redesign of the engine air-intake tube

c. abating exahaust noise through installation of a new, double-skinned muffler and a new exhaust resonator, and through resign and shortening of the exhaust pipes to the muffler

d. abating cooling-system noise through design and installation of a larger radiator (if it should prove to be feasible), design and installation of an aerodynamically efficient radiator fan and design and installation of an improved venturi radiator shroud. The feasibility of using a variable-speed electric, or hydraulic, fan drive to be controlled thermostatically would also be investigated.

e. providing acoustical treatment to the engine compartment by installing sound-absorptive materials on all available surfaces. Also, the noise reduction that could be achieved through the use of belly pans was to be determined (belly pans are covers placed underneath the engine, normally for the purpose of keeping road dust and dirt out of the engine compartment.)

4. Conducting acoustical tests on the noise-treated buses

5. Conducting performance tests on the noise-treated buses

6. Evaluating the overall effectiveness of the noise-reduction package and possibly modifying the design to achieve the maximum noise reduction.

One of the consultants to Tri-Met explained some of the technical considerations that went into formulating the work plan as follows:

> The lowest possible noise level which can be achieved by any bus at a particular speed is represented by the coasting condition. This noise is a combination of several sources including tires, wheel and axle bearings, gears of the transmission in neutral, body creaks and aerodynamic noise. This is known as 'chassis' noise and sets the lower limit of the noise reduction effort.
>
> Further, engine mechanical noise is radiated (and therefore presents the most serious problem) from the engine structure where there are areas of low mass and high stiffness. The two worst areas are the valve rocker covers and the oil pan. They should be either modified or replaced to achieve a greater mass and adequate damping. The planned double-skinned replacement valve rocker covers and oil pan should weigh twice as much as the current parts and should be fully damped. Engine mechanical noise should be reduced by 2 to 3 dBA. Air-intake noise may already be at a minimum. The contribution to overall noise will have to be determined by test.

The object of modifying the cooling system would be to slow down the cooling fan and also reduce its running time. In the new cooling package the fan drive would no longer be attached directly to the engine; the whole package would be mounted to the bus body on anti-vibration mounts. The only connection to the engine would be the flexible coolant hoses. The noise reduction achievable with small tip clearances, well-designed shrouds, and slower fan speeds might exceed 15 dBA.

The objectives of the Phase I studies were summarized thus:[1]

> The ultimate objective of this project is to demonstrate the amount of noise reduction possible in today's transit buses through the

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[1] Statement of Work, DOT Project OR-06-0005.

application of existing acoustical engineering technology without serious compromise to bus operation and maintenance parameters.

The immediate objective of Phase I is to provide definition to an engineering prototype configuration and demonstrate and project preliminary engineering and economic results of fleet-wide application.

The engineering prototype configuration will be characterized by the following:

- Will provide a five-to-seven dBA noise reduction when tested under EPA procedure

- Will have a broad range of application to existing bus configurations

- Will have no serious effect on:
  Fuel and oil consumption
  Vehicle air emissions
  Engine and cooling-system life
  Vehicle performance
  Vehicle maintainability
  Passenger space
  Vehicle visual appearance
  Noise impact on surrounding area

- Acoustical engineering technology may be applied to the following vehicle component areas:
  Exaust
  Air Intake
  Cooling system Engine compartment Passenger-compartment enclosures

- Result in favorable life-cycle cost projections

Technical Progress

Tri-Met's consultant documented his activities by means of monthly progress reports. The following information in this section has been extracted from these reports.

Baseline measurements were obtained from two 1972 Flxible buses from the Tri-Met fleet. Both were equipped with Detroit Diesel engines, type 8V-71N.[1] Tested in accordance with the EPA rating method, both buses yielded a baseline noise rating of about 80 dBA at 50 ft. Noise-source identification analysis revealed that the engine compartment is the major contributor to the overall noise level of the buses. Results of the noise-source identification are given in the baseline column of Table 1.

Since detailed information on how to perform the retrofit is given in Appendix C, details of the retrofit will not be described in this part of the report. Since it was clear that engine compartment noise is the major contributor to bus noise, the engine compartment received first consideration in testing abatement technology. Unfortunately, one of the first attempts proved to have little usefulness. Thin steel valve covers were replaced with aluminum valve covers, but they had no significant effect on bus noise (less than 1 dBA). Other modifications to the engine compartment were, however, more successful. These modifications included:

- Installation of a turbocharged engine,
- Installation of acoustical insulation in the engine compartment,
- Increasing the size of the radiator grill.[2]

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[1] This designation means that the engine has 8 cylinders in a V arrangement with a displacement 71 cubic in. and normally aspirated (not turbocharged).

[2] This modification was installed to increase cooling capacity not to provide an acoustic improvement.

TABLE 1. SOURCE LEVEL CONTRIBUTIONS TO EXTERIOR EPA NOISE RATING (dBA)[a]

	Left Side			Right Side			Average[b]		
	Baseline	Demonstrated	Expected	Baseline	Demo	Expected	Baseline	Demo.	Expected
Engine	79	77	75.8	78	72.4	72.4	-	-	-
Fan	77.2	79.5	79.5	76.5	75.8	75.8	-	-	-
Shell	73	nil	nil	70	nil	nil	-	-	-
Exhaust	66	69.5	66	65	68.5	65	-	-	-
Tires	58	58	58	58	58	58	-	-	-
TOTAL[c]									
Fan Normal	80.2	77	76.2	79	74*	73.2	79.5	75.5	74.8
Fan On	82	81.5	81	81	78*	77.5	81.5	79.5	79.4

Expected Reduction of Exterior EPA Noise Rating from Baseline			
	Left Side	Right Side	Average[b]
Fan Normal	4	5.8	≈4.9
Fan On	1	3.5	≈2

[a] Treatment optimized to "No Bellypan" Level; values rounded to nearest 0.1 dB.

[b] Arithmetic mean of dB.

[c] In the "Fan On" condition, the fan is running continuously; fan noise is considered negligible in the "Fan Normal" condition.

*Please note minor discrepancies between Table 1 and Table 5. Data in Table 1 are based on later measurements.

A summary of the results of these further modifications is given in Table 1. It is interesting to note as an example of the way components in a system interact that installation of the turbocharger produced about a 3 dBA increase in exhaust noise if the Exhaust system remains untreated.

With a substantial decrease in noise from the engine compartment achieved, attention could now be devoted to two other important sources, the muffler shell and the exhaust. The muffler shell was wrapped with lead and a stack silencer was added to the exhaust system. A stack silencer consists of an auxiliary muffler substituted for the usual straight stack ending usually found after the standard muffler. In addition, the exhaust of the air dryer was treated to eliminate air-dryer hiss. Air-dryer hiss is the hissing sound frequently heard by onlookers when the bus pulls away from a curb. An air exhaust muffler was installed, and the exhaust from the air dryer was fed into the engine exhaust system. Air-dryer hiss was, in this fashion, virtually eliminated. The results of the treatments installed and tested by the end of Phase I of the project are provided in Table 1.[1]

Tri-Met's consultant was able to demonstrate an improvement of about 3.5 dBA for the left side and 5 dBA improvement for the right side. The arithmetic average noise level was improved by about 4 dBA overall to about 75.5 dBA. These are sound levels for fan normal, the normal way in which the cooling system functions when the bus is in service. The greatest gains in quieting were attained in reducing engine noise and exhaust-shell noise. Engine-noise improvements are attributable to turbocharging and to use of the engine-compartment lining. Average exhaust muffler noise had actually gone up by 3 dBA and average fan noise had increased by about 1 dBA. As shown in the right-hand entries of the tabulation, the consultant felt that 3 dBA quieting of the exhaust was within reach. With achievement of the expected improvement, the net noise rating with fan normal becomes 75.5 dBA. It should be noted that the engine, cooling system, and exhaust system are designed asymmetrically so that the left side of transit buses is typically somewhat noiser than the right side, about 1 dBA overall for the baseline rating.

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[1] Data have recently been made available for a Generalk Motors bus. the results of these acoustical treatments in addition to the results for the Flxible bus are given in Appendix D.

A service bulletin has been developed that is a set of standard specifications for a noise kit to tell bus operators in other cities how they too can modify existing engine installations to get noise-quieting results similar to those obtained with the Tri-Met fleet in Portland. (See Appendix C.)

All of the noise treatments listed in Table 1 were considered by the management of Tri-Met to be acceptable from an operational point of view. Tri-Met's consultant developed a list of additional changes that he felt are within the realm of possible application though they would push the retrofit treatment much closer to the limits of available technology. "Insertion loss" is the improvement in sound level (dBA) as a result of the particular treatment. Each entry in a column in Table 2 is an additive improvement. Of the modifications listed in Table 2, the belly pan undoubtedly meets with the most disfavor from managers of bus fleets because it is considered to be a nuisance to bus maintenance. In fact, Tri-Met has ordered that all of the buses it purchases be delivered without the belly pan even though it is standard equipment. However, the consultant believes that an efficient belly pan can be designed that will not hinder maintenance.

Tri-Met had hoped to receive federal funding to apply the noise kit to its entire fleet, but UMTA policy then required a 12-year service life for financial assistance to improve equipment, which excluded most of the Portland bus fleet from eligibility.[1] While waiting for further developments on fleet quieting, Tri-Met has asked for, and expects to get, grant money to purchase 57 new articulated buses, called ICARUS. They will come with turbocharged, aftercooled engines leading to both quiet operation and improved fuel economy. They are expected to achieve a 79 or 80 dBA noise level similar to the flexible bus as delivered as well as to provide additional transportation economy. Since the articulated design provides additional space for passengers, one driver will

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[1] This policy was later clarified to permit retrofit of buses with service lives of less than 12 years (See Appendix E).

TABLE 2
INSERTION LOSSES FOR ADDITIONAL TREATMENTS CONSIDERED POSSIBLE

	INSERTION LOSS	
ADDITIONAL TREATMENTS	Engine	Fan
Full belly pan	1.0	6.1
Engine mounts	2.0	0
Improved lining	3.2	1.2
Fuel-control tradeoff	2.0	-

be able to serve a much larger number of passengers, as many as 100-200 passengers in all. However, the fact that there are economies to be gained by purchasing equipment of more advanced design must not draw attention from the fact that retrofit of equipment in current use remains a viable option to reduce noise in an operating fleet.

APPENDIX A

NOISE CRITERIA OF THE U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

federal register

Thursday
July 12, 1979

Part V

Department of Housing and Urban Development

Office of the Secretary

Environmental Criteria and Standards

A-2

HOUSING AND URBAN DEVELOPMENT

24 CFR Part 51

[Docket No. R-79-595]

Environmental Criteria and Standards

AGENCY: Department of Housing and Urban Development.

ACTION: Final rule.

SUMMARY: This final rule adds a new Part 51, Environmental Criteria and Standards to Title 24 of the CFR. The rule sets forth Subparts A and B covering General Provisions and Noise Abatement and Control respectively.

EFFECTIVE DATE: August 13, 1979.

FOR FURTHER INFORMATION CONTACT: James F. Miller or Gretchen Van Hyning, Office of Environmental Quality, Room 7266, U.S. Department of Housing and Urban Development, 451 7th Street, SW., Washington, 20410 D.C. (202) 755–8909 (this is not a toll-free number).

SUPPLEMENTAL INFORMATION: A Notice of Proposed Rulemaking was published on December 27, 1978 (43 FR 60396) indicating that HUD proposed to add a new Part 51, Environmental Criteria and Standards, to Title 24 of the CFR. The proposed rule would include Subpart A, General Provisions, and Subpart B, Noise Abatement and Control. The Notice invited public comment until January 26, 1979.

Subpart B establishes Departmental standards, requirements, and guidelines on noise abatement and control, replacing and revising the noise policies, standards and procedures previously set forth in HUD Circular 1390.2, which is cancelled when this final rule becomes effective.

Subpart B converts the existing noise policy to regulation format and makes revision and improvements intended to make the policy more flexible and consistent with other Federal agencies' noise programs. Revisions to the current policy (1) bring into conformity, through the use of the day-night average sound level, separate standards and measurements for aircraft and non-aircraft noise; (2) afford Field Offices more flexibility in implementing the policy thus reducing the number of cases having to come into the Region and Headquarters Offices; (3) remove the dual exterior and interior standards, hence, if exterior noise levels are found to be acceptable, the interior noise will be considered acceptable using normal building techniques; and (4) allow easy use of already existing data, particularly from FHWA and DOD. The standards apply primarily to HUD support for new residential construction in certain noise zones—as does the existing policy.

Overall, the comments indicated strong support for the revisions to the noise policy, particularly the use of the day-night average sound level descriptor and the acceptability thresholds used by the Department. The one topic which generated substantial discussion and a divergence of opinion was the methodology for describing "loud implusive sounds."

The following discussion summarizes the significant comments and the changes that were made in the final rule.

1. *Use of the Day-Night Average Sound Level (DNL) to Describe Noise.*—Of the 18 responses, 15 commented on the proposed noise descriptor. Only two of these expressed reservations (one Federal agency and one industry group) about use of the day-night average sound level; these two comments were directed to use of a nighttime penalty in DNL. Both parties recommended substituting a computer based model which itself, among other things, incorporates a nighttime penalty. The same agency has also issued advisory materials containing noise metrics which include the nighttime correction.

The proposed methodology for describing noise has been widely used to relate individual and community reaction to aircraft and road traffic noise, to predict the likelihood and the severity of interference with speech and sleep, and to correlate hearing loss with noise exposure. The simple concept of average sound level must be somewhat refined to account for the fact, documented by most community response and public opinion surveys, that the same noise level is considered more disturbing or annoying during the nighttime than during daytime. Not only do the requirements for undisturbed sleep and relaxation make a lower nighttime noise level desirable, but the exterior background noise level in most communities drops during the night by 10 dB or more and reduced activity inside homes contributes to a general lowering of interior noise levels. Consequently, intrusive noises are more disturbing during the night. To assess nighttime noise events in a way that accounts for their increased potential for causing disturbances a weighting factor of 10 dB is applied to all nighttime noises; i.e., nighttime noises are treated as if they were 10 dB noiser than they actually are. The need for a nighttime correction has also received international concensus through the International Organization for Standardization (ISO).

In view of the acceptance and support for the DNL descriptor, HUD is publishing the final rule using the DNL with the nighttime correction for application of the standards.

2. *Proposed Standards.*—Most responses indicated the appropriateness of the general goals and levels proposed by HUD. Two responses however indicated concern that noise transmitted within multifamily dwellings was not addressed. This problem is however covered in Section 51.101(a)(10): the relevant reference to the Minimum Property Standards for Multifamily Housing is Section 404 on Acoustic Control.

Several comments related to conversion of existing data to DNL. The conversion factors have been clarified in the final rule and the conversion indicates the measures "are approximately equal to" rather than the same. In the final rule one descriptor for aircraft noise was added—(Community Noise Equivalent Level, used in California) and one was deleted (Composite Noise Rating). The Composite Noise Rating methodology was developed in the early 1960's and is subject to error and is used only infrequently and therefore it has been dropped from the final rule (see Section 51.106).

Conversion of highway levels (Section 51.106) to DNL is discussed in the National Cooperative Highway Research Program Report No. 173 on "Highway Noise Generation and Control," published by the Transportation Research Board in 1976.

3. *Analysis of Loud Impulsive Sounds.*—Five responses were directed to the methodology for calculating "loud impulsive sounds." The method for characterizing noise from explosions or sonic booms proposed by HUD in Section 103(b) is consistent with the interim procedures of the Department of Defense. HUD recognizes that the subject is currently undergoing technical debate, but no alternative has emerged upon which the technical community has agreed. This method is likely to be applied mostly in rare instances where sites are proposed in the vicinity of artillery firing ranges or other similar activities. In view of the current debate the final rule has been amended, in the text and in the Appendix, to emphasize that this methodology is to be used on an *interim basis.* When a final procedure is adopted by all the concerned Federal agencies, HUD's rule will be changed to incorporate the agreed upon methodology.

4. *Noise Attenuation.*—It was recommended by one reviewer that noise attenuation be expressed in terms of total sound attenuation rather than the requirement for attenuation measures in addition to the attenuation provided by housing as commonly constructed in the area. The results are essentially the same and both approaches have been considered. It was determined that the suggested approach by the reviewer may overstate the requirements while HUD's policy is to state minimum requirements to provide adequate protection at minimum cost. The final rule was changed to indicate that the additional noise attenuation measures are minimum requirements.

5. *Other Comments.*—Several reviewers provided editorial and technical corrections which have been included in the final rule. Some comments were not relevant to the specific rule, while other suggested that the Department prepare documents setting forth the rationale for the HUD standards and provide guidance to local governments. This work is underway, and a revised "Noise Assessment Guidelines" document should be available by the time the rule becomes effective. A technical background report on the policy is also in preparation and will be available at a later date. Two reviewers also suggested that HUD develop a procedure for notifying purchasers of existing properties if noise levels exceed those of the established regulation. HUD does consider noise as a marketability factor in Section 51.101(a)(4) in determining the amount of insurance or other assistance that may be given but does not propose to include a specific additional notification procedure in the appraisal process.

Some reviewers suggested that HUD take a major role in Federal efforts to control noise. HUD is cooperating with the EPA, DOT and DOD in interagency noise programs; these other agencies have responsibility for controlling noise at the source. HUD's regulations are necessarily limited to programs administered by the Department; however, the standards and guidance material should assist local governmental agencies and others in formulating policies to achieve quieter urban environments.

OTHER INFORMATION: A Finding of Inapplicability with regard to Environmental Impact has been prepared in accordance with HUD's environmental procedures. Copies of the statement and findings are available for inspection and copying in the Office of the Rules Docket Clerk, Room 5218, Department of Housing and Urban Development, 451 7th Street, S.W., Washington, D.C. 20410.

Accordingly, Title 24 of the CFR is amended by adding a new Part 51 to read as follows:

PART 51—ENVIRONMENTAL CRITERIA AND STANDARDS

Subpart A—General Provisions

Sec.

51.1 Purpose.
51.2 Authority.
51.3 Responsibilities.
51.4 Program coverage.
51.5 Coordination with environmental clearance requirements.
51.6 [Reserved]

Subpart B—Noise Abatement and Control

51.100 Purpose and authority.
51.101 General policy.
51.102 Responsibilities.
51.103 Criteria and standards.
51.104 Special requirements.
51.105 Exceptions.
51.106 Implementation.

Appendix

Authority: Sec. 7(d), Department of HUD Act (42 U.S.C. 3535(d)).

Subpart A—General Provisions

§ 51.1 Purpose.

The Department of Housing and Urban Development is providing program Assistant Secretaries and administrators and field offices with environmental standards, criteria and guidelines for determining project acceptability and necessary mitigating measures to insure that activities assisted by the Department achieve the goal of a suitable living environment.

§ 51.2 Authority.

This Part implements the Department's responsibilities under the following statutes:

(a) The National Housing Act of 1934 (Pub. L. 73–479) which was enacted "to encourage improvements in housing standards and conditions, to provide a system of mutual mortgage insurance, and for other purposes," thus providing the basis for HUD's Minimum Property Standards (MPS) which have evolved as required by legislation over the past 44 years.

(b) The Housing Act of 1949 (Pub. L. 81–171) which sets forth the national goal of "a decent home and a suitable living environment for every American family," affirmed by the Housing and Urban Development Act of 1968 (Pub. L. 90–448).

(c) The Department of Housing and Urban Development Act of 1965 (Pub. L. 89–174) which provides that the Secretary may make such rules and regulations as may be necessary to carry out functions, powers, and duties, and sets forth, as a matter of national purpose, the sound development of the Nation's communities and metropolitan areas.

(d) The National Environmental Policy Act of 1969 (Pub. L. 91–190) which directs Federal agencies to develop procedures to carry out the purposes of the Act.

(e) Intergovernmental Cooperation Act of 1968 (Pub. L. 90–577) which, under Title IV, directs that Federal programs and projects serve the objectives of appropriate land use for housing, commercial, industrial, governmental, institutional, and other purposes to achieve sound and orderly development of all areas, both urban and rural.

§ 51.3 Responsibilities.

(a) *Assistant Secretary for Community Planning and Development.* The Assistant Secretary for Community Planning and Development shall be responsible for administering environmental regulations, and shall provide oversight, interpretation and guidance, and shall update the regulations as required. The Assistant Secretary shall also maintain liaison with other Federal agencies on matters of environmental policy implementation.

(b) *Assistant Secretary for Policy Development and Research.* The Assistant Secretary for Policy Development and Research shall undertake research and demonstration studies necessary for the technical development of environmental standards, criteria, and implementing techniques as a basis for the development and implementation of environmental regulations. The Assistant Secretary shall also maintain liaison with Federal agencies on related technical matters.

(c) *Other Assistant Secretaries, Administrators, and the General Counsel.* Other Assistant Secretaries, Administrators, and the General Counsel shall:

(1) Incorporate adopted environmental regulations by reference into program regulations, guidance documents, and administrative forms and procedures;

(2) Evaluate the effects of, and compliance with Departmental environmental regulations policy and report significant issues and problems to the Assistant Secretary for Community Planning and Development; and

(3) Identify program areas under their jurisdiction in which additional

environmental regulations are needed, and refer them to the Assistant Secretary for Community Planning and Development.

(d) *Regional Administrators, Area Office Managers and Service Office Supervisors.* Regional Administrators, Area Office Managers and Service Office Supervisors shall assure that adopted environmental regulations are implemented in relation to program decisions and recommendations. They shall also monitor projects to assure that mitigation measures are implemented.

§ 51.4 Program coverage.

Environmental standards shall apply to all HUD actions except where special provisions and exemptions are contained in each Subpart.

§ 51.5 Coordination with environmental clearance requirements.

Environmental standards shall be implemented prior to commitment in the decision-making process and, where environmental clearances are required, the decision points shall be identical. Compliance with HUD environmental standards shall be addressed in the environmental clearance process.

§ 51.6 [Reserved]

Subpart B—Noise Abatement and Control

§ 51.100 Purpose and authority.

(a) *Purpose.* The Department of Housing and Urban Development finds that noise is a major source of environmental pollution which represents a threat to the serenity and quality of life in population centers and that noise exposure may be a cause of adverse physiological and psychological effects as well as economic losses.

It is the purpose of this Subpart to:

(1) Call attention to the threat of noise pollution;

(2) Encourage the control of noise at its source in cooperation with other Federal departments and agencies;

(3) Encourage land use patterns for housing and other noise sensitive urban needs that will provide a suitable separation between them and major noise sources;

(4) Generally prohibit HUD support for new construction of noise sensitive uses on sites having unacceptable noise exposure;

(5) Provide policy on the use of structural and other noise attenuation measures where needed; and

(6) Provide policy to guide implementation of various HUD programs.

(b) *Authority.* Specific authorities for noise abatement and control are contained in:

(1) The Noise Control Act of 1972 (Pub. L. 92–574) which directs Federal agencies to administer their programs in ways which reduce noise pollution.

(2) The Quiet Communities Act of 1978 (Pub. L. 95–609) which amended Pub. L. 92–574.

(3) The General Services Administration, Federal Management Circular 75–2: *Compatible Land Uses at Federal Airfields* prescribes the Executive Branch's general policy with respect to achieving compatible land uses on either public or privately owned property at or in the vicinity of Federal airfields.

(4) Section 1113 of the Housing and Urban Development Act of 1965 (Pub. L. 89–117) directs the Secretary "* * * to determine feasible methods of reducing the economic loss and hardships suffered by homeowners as a result of the depreciation in the value of their properties following the construction of airports in the vicinity of their homes, including a study of feasible methods of insulating such homes from the noise of aircraft."

§ 51.101 General policy.

(a) It is HUD's general policy to provide minimum national standards applicable to HUD programs to protect citizens against excessive noise in their communities and places of residence.

(1) *Comprehensive planning assistance.* HUD requires that grantees give adequate consideration to noise exposures and sources of noise as an integral part of the urban environment in HUD assisted comprehensive planning, as follows:

(i) Particular emphasis shall be placed on the importance of compatible land use planning in relation to airports, highways and other sources of high noise.

(ii) Applicants shall take into consideration HUD environmental standards impacting the use of land as required in 24 CFR Part 600.

(iii) Environmental studies, including noise assessments, are allowable costs.

(2) *Community Development Block Grants.* Recipients of community development block grants under the Housing and Community Development Act of 1974 (Pub. L. 93–383), as amended by the Housing and Community Development Act of 1977 (Pub. L. 95–128), must take into consideration the noise criteria and standards in the environmental review process and consider ameliorative actions when noise sensitive land development is proposed in noise exposed areas. Grant recipients shall address deviations from the standards in their environmental reviews as required in 24 CFR Part 58.

Where CDBG activities are planned in a noisy area, and HUD assistance is contemplated later for housing and/or other noise sensitive activities, the CDBG grantee risks denial of the HUD assistance unless the HUD standards are met. Environmental studies, including noise assessments, are allowable costs.

(3) *HUD support for new construction.* HUD assistance for the construction of new noise sensitive uses is prohibited generally for projects with Unacceptable noise exposures and is discouraged for projects with Normally Unacceptable noise exposure. (Standards of acceptability are contained in § 51.103(c).) This policy applies to all HUD programs providing assistance, subsidy or insurance for housing, college housing, mobile home parks, nursing homes, hospitals, and all programs providing assistance or insurance for land development, new communities, redevelopment or any other provision of facilities and services which are directed to making land available for housing or noise sensitive development. The policy does not apply to research demonstration projects which do not result in new construction or reconstruction, flood insurance, interstate land sales registration, or any action or emergency assistance under disaster assistance programs which are provided to save lives, protect property, protect public health and safety, remove debris and wreckage, or assistance provided that has the effect of restoring facilities substantially as they existed prior to the disaster.

(4) *HUD support for existing construction.* Noise exposure by itself will not result in the denial of HUD support for the resale and purchase of otherwise acceptable existing buildings. However, environmental noise is a marketability factor which HUD will consider in determining the amount of insurance or other assistance that may be given.

(5) *HUD support of modernization and rehabilitation.* For modernization projects located in all noise exposed areas, HUD shall encourage noise attenuation features in alterations. For major or substantial rehabilitation projects in the Normally Unacceptable and Unacceptable noise zones, HUD actively shall seek to have project sponsors incorporate noise attenuation features, given the extent and nature of the rehabilitation being undertaken and the level or exterior noise exposure. In

Unacceptable noise zones. HUD shall strongly encourage conversion of noise-exposed sites to land uses compatible with the high noise levels.

(6) *Research, guidance and publications.* HUD shall maintain a continuing program designed to provide new knowledge of noise abatement and control to public and private bodies, to develop improved methods for anticipating noise encroachment, to develop noise abatement measures through land use and building construction practices, and to foster better understanding of the consequences of noise. It shall be HUD's policy to issue guidance documents periodically to assist HUD personnel in assigning an acceptability category to projects in accordance with noise exposure standards, in evaluating noise attenuation measures, and in advising local agencies about noise abatement strategies. The guidance documents shall be updated periodically in accordance with advances in the state-of-the-art.

(7) *Construction equipment, building equipment and appliances.* HUD shall encourage the use of quieter construction equipment and methods in population centers, the use of quieter equipment and appliances in buildings, and the use of appropriate noise abatement techniques in the design of residential structures with potential noise problems.

(8) *Exterior noise goals.* It is a HUD goal that exterior noise levels do not exceed a day-night average sound level of 55 decibels. This level is recommended by the Environmental Protection Agency as a goal for outdoors in residential areas. The levels recommended by EPA are not standards and do not take into account cost or feasibility. For the purposes of this regulation and to meet other program objectives, sites with a day-night average sound level of 65 and below are acceptable and are allowable (see Standards in § 51.103(c)).

(9) *Interior noise goals.* It is a HUD goal that the interior auditory environment shall not exceed a day-night average sound level of 45 decibels. Attenuation measures to meet these interior goals shall be employed where feasible. Emphasis shall be given to noise sensitive interior spaces such as bedrooms. Minimum attenuation requirements are prescribed in § 51.104(a).

(10) *Acoustical privacy in multifamily buildings.* HUD shall require the use of building design and acoustical treatment to afford acoustical privacy in multifamily buildings pursuant to requirements of the Minimum Property Standards.

§ 51.102 Responsibilities.

(a) *Authority to approve projects.* (1) Decisions on proposed projects with acceptable noise exposures shall be delegated to the program personnel within field offices, including projects where increased noise levels are considered acceptable because of non-acoustic benefits under § 51.105(a). Field office program personnel may also approve projects in normally unacceptable noise exposed areas where adequate sound attenuation is provided and where the project does not require an Environmental Impact Statement under § 51.104(b).

(2) Other approvals in normally unacceptable noise exposed areas require the concurrence of the Regional Administrator.

(3) Requests for approvals of projects or portions of projects with unacceptable noise exposures shall be referred through the Regional Office to the Assistant Secretary for Community Planning and Development for approval pursuant to § 51.104(b).

(4) In cases where the Regional Administrator determines that an important precedent or issue is involved, such cases shall be referred with recommendations to the Assistant Secretary for Community Planning and Development.

(b) *Surveillance of noise problem areas.* Appropriate field staff shall maintain surveillance of potential noise problem areas and advise local officials, developers, and planning groups of the unacceptability of sites because of noise exposure at the earliest possible time in the decision process. Every attempt shall be made to insure that applicants' site choices are consistent with the policy and standards contained herein.

(c) *Notice to applicants.* At the earliest possible stage, HUD program administrators shall:

(1) Determine the suitability of the acoustical environment of proposed projects;

(2) Notify applicants of any adverse or questionable situations; and

(3) Assure that prospective applicants are apprised of the standards contained herein so that future site choices will be consistent with these standards.

(d) *Technical assistance.* Technical assistance in the measurement, estimation, interpretation, or prediction of noise exposure is available from the Office of Community Planning and Development and the Office of Policy Development and Research. Field office questions shall be forwarded through the Regional Office to the Assistant Secretary for Community Planning and Development or his designee.

(e) *Interdepartmental coordination.* Regional Administrators shall foster appropriate coordination between field offices and other departments and agencies, particularly the Environmental Protection Agency, the Department of Transportation, Department of Defense representatives, and the Veterans Administration. HUD staff shall utilize the acceptability standards in commenting on the prospective impacts of transportation facilities and other noise generators in the Environmental Impact Statement review process.

§ 51.103 Criteria and standards.

These standards apply to all programs as indicated in § 51.101.

(a) *Measure of external noise environments.* The magnitude of the external noise environment at a site is determined by the value of the day-night average sound level produced as the result of the accumulation of noise from all sources contributing to the external noise environment at the site. Day-night average sound level, abbreviated as DNL and symbolized as L_{dn}, is the 24-hour average sound level, in decibels, obtained after addition of 10 decibels to sound levels in the night from 10 p.m. to 7 a.m. Mathematical expressions for average sound level and day-night average sound level are stated in the Appendix.

(b) *Loud impulsive sounds.* On an interim basis, when loud impulsive sounds, such as explosions or sonic booms, are experienced at a site, the day-night average sound level produced by the loud impulsive sounds alone shall have 8 decibels added to it in assessing the acceptability of the site (see Appendix). Alternatively, the C-weighted day-night average sound level (L_{Cdn}) may be used without the 8 decibel addition, as indicated in Section 51.106(a)(3).

Methods for assessing the contribution of loud impulsive sounds to day-night average sound level at a site and mathematical expressions for determining whether a sound is classed as "loud impulsive" are provided in the Appendix.

(c) *Exterior standards.* The degree of acceptability of the noise environment at a site is determined by the sound levels external to buildings or other facilities containing noise sensitive uses. The standards shall usually apply at a location 2 meters (6.5 feet) from the building housing noise sensitive activities in the direction of the predominant noise source. Where the building location is undetermined, the standards shall apply 2 meters (6.5 feet) from the building setback line nearest to the predominant noise source. The standards shall also apply at other locations where it is determined that quiet outdoor space is required in an area ancillary to the principal use on the site.

The noise environment inside a building is considered acceptable if (a) the noise environment external to the building complies with these standards, and (b) the building is constructed in a manner common to the area or, if of uncommon construction, has at least the equivalent noise attenuation characteristics.

Site Acceptability Standards

	Day-night average sound level (in decibels)	Special approvals and requirements
Acceptable	Not exceeding 65 dB(1)	None
Normally Unacceptable	Above 65 dB but not exceeding 75 dB	Special Approvals (2) Environmental Review (3) Attenuation (4)
Unacceptable	Above 75 dB	Special Approvals (2) Environmental Review (3) Attenuation (5)

Notes.—(1) Acceptable threshold may be shifted to 70 dB in special circumstances pursuant to Section 51.105(a).

(2) See Section 51.104(b) for requirements.

(3) See Section 51 104(b) for requirements.

(4) 5 dB additional attenuation required for sites above 65 dB but not exceeding 70 dB and 10 dB additional attenuation required for sites above 70 dB but not exceeding 75 dB. (See Section 51 104(a).)

(5) Attenuation measures to be submitted to the Assistant Secretary for CPD for approval on a case-by-case basis.

§ 51.104 Special requirements.

(a) *Noise attenuation.* Noise attenuation measures are those required in addition to attenuation provided by buildings as commonly constructed in the area, and requiring open windows for ventilation. Measures that reduce external noise at a site shall be used wherever practicable in preference to the incorporation of additional noise attenuation in buildings. Building designs and construction techniques that provide more noise attenuation than typical construction may be employed also to meet the noise attenuation requirements.

(1) *Normally Unacceptable noise zone.* Approvals in this zone require a minimum of 5 decibels additional sound attenuation for buildings having noise-sensitive uses if the day-night average sound level is greater than 65 decibels but does not exceed 70 decibels, or a minimum of 10 decibels of additional sound attenuation if the day-night average sound level is greater than 70 decibels but does not exceed 75 decibels.

(2) *Unacceptable noise zone.* Noise attenuation measures require the approval of the Assistant Secretary for Community Planning and Development. (See § 51.104(b)(2).)

(b) *Special Approvals and Environmental Review Requirements.* Environmental clearances shall be conducted pursuant to the requirements of HUD's Departmental Policies, Responsibilities and Procedures for Protection and Enhancement of Environmental Quality (38 FR 19182 as amended) or other environmental regulations which may be issued by the Department. The Special Clearance and Environmental Impact Statement (EIS) threshold requirements are hereby modified for all projects proposed in the Normally Unacceptable and Unacceptable noise exposure zones as follows:

(1) *Normally Unacceptable noise zone.* (i) All projects located in the Normally Unacceptable Noise Zone require a Special Environmental Clearance except an EIS is required for a proposed project located in a largely undeveloped area, or where the HUD action is likely to encourage the establishment of incompatible land use in this noise zone.

(ii) When an EIS is required, the concurrence of the Regional Administrator is also required before a project can be approved. For the purposes of this paragraph, an area will be considered as largely undeveloped unless the area within a 2-mile radius of the project boundary is more than 50 percent developed for urban uses and infrastructure (particularly water and sewers) is available and has capacity to serve the project.

(iii) All other projects in the Normally Unacceptable zone require a Special Environmental Clearance, except where an EIS is required for other reasons pursuant to HUD environmental policies.

(2) *Unacceptable noise zone.* An EIS is required prior to the approval of projects with unacceptable noise exposure. Projects in or partially in an Unacceptable Noise Zone shall be submitted through the Regional Administrator to the Assistant Secretary for Community Planning and Development for approval. The Assistant Secretary may waive the EIS requirement in cases where noise is the only environmental issue and no outdoor sensitive activity will take place on the site. In such cases, a Special Environmental Clearance is required.

§ 51.105 Exceptions.

(a) *Flexibility for non-acoustic benefits.* Where it is determined that program objectives cannot be achieved on sites meeting the acceptability standard of 65 decibels, the Acceptable Zone may be shifted to L_{dn} 70 on a case-by-case basis if all the following conditions are satisfied:

(1) The project does not require an Environmental Impact Statement under provisions of section 104(b)(1) and noise is the only environmental issue.

(2) The project has received a Special Environmental Clearance and has received the concurrence of the Environmental Clearance Officer.

(3) The project meets other program goals to provide housing in proximity to employment, public facilities and transportation.

(4) The project is in conformance with local goals and maintains the character of the neighborhood.

(5) The project sponsor has set forth reasons, acceptable to HUD, as to why the noise attenuation measures that would normally be required for new construction in the L_{dn} 65 to L_{dn} 70 zone cannot be met.

(6) Other sites which are not exposed to noise above L_{dn} 65 and which meet program objectives are generally not available.

The above factors shall be documented and made part of the project file.

§ 51.106 Implementation.

(a) *Use of available data.* HUD field staff shall make maximum use of noise data prepared by others when such data are determined to be current and adequately projected into the future and are in terms of the following:

(1) *Sites in the vicinity of airports.* The noise environment around airports is described sometimes in terms of Noise Exposure Forecasts, abbreviated as NEF or, in the State of California, as

Community Noise Equivalent Level, abbreviated as CNEL. The noise environment for sites in the vicinity of airports for which day-night average sound level data are not available may be evaluated from NEF or CNEL analyses using the following conversions to DNL:

$\mathrm{DNL} \simeq \mathrm{NEF} + 35$
$\mathrm{DNL} \simeq \mathrm{CNEL}$

(2) *Sites in the vicinity of highways.* Highway projects receiving Federal aid are subject to noise analyses under the procedures of the Federal Highway Administration.

Where such analyses are available they may be used to assess sites subject to the requirements of this standard. The Federal Highway Administration employs two alternate sound level descriptors: (a) The A-weighted sound level not exceeded more than 10 percent of the time for the highway design hour traffic flow, symbolized as L_{10}; or (b) the equivalent sound level for the design hour, symbolized as L_{eq}. The day-night average sound level may be estimated from the design hour L_{10} or L_{eq} values by the following relationships, provided heavy trucks do not exceed 10 percent of the total traffic flow in vehicles per 24 hours and the traffic flow between 10 p.m. and 7 a.m. does not exceed 15 percent of the average daily traffic flow in vehicles per 24 hours:

$\mathrm{DNL} \simeq L_{10}$ (design hour)—3 decibels
$\mathrm{DNL} \simeq L_{eq}$ (design hour) decibels

Where the auto/truck mix and time of day relationships as stated in this Section do not exist, the HUD Noise Assessment Guidelines or other noise analysis shall be used.

(3) *Sites in the vicinity of installations producing loud impulsive sounds.* Certain Department of Defense installations produce loud impulsive sounds from artillery firing and bombing practice ranges. Noise analyses for these facilities sometimes encompass sites that may be subject to the requirements of this standard. Where such analyses are available they may be used on an interim basis to establish the acceptability of sites under this standard.

The Department of Defense uses day-night average sound level based on C-weighted sound level, symbolized L_{Cdn}, for the analysis of loud impulsive sounds. Where such analyses are provided, the 8 decibel addition specified in 51.103(b), is not required, and the same numerical values of day-night average sound level used on an interim basis to determine site suitability for non-impulsive sounds apply to the L_{Cdn}.

(4) *Use of areawide acoustical data.* HUD encourages the preparation and use of areawide acoustical information, such as noise contours for airports. Where such new or revised contours become available for airports (civil or military) and military installations they shall first be referred to the Regional Office (Environmental Clearance Officer) for review, evaluation and decision on appropriateness for use by HUD. The Regional Office shall submit revised contours to the Assistant Secretary of Community Planning and Development for review, evaluation and decision whenever the area affected is changed by 20 percent or more, or whenever it is determined that the new contours will have a significant effect on HUD programs, or whenever the contours are not provided in a methodology acceptable under § 51.106(a)(1) or in other cases where the Regional Office determines that Headquarters review is warranted. For other areawide acoustical data, review is required only where existing areawide data are being utilized and where such data have been changed to reflect changes in the measurement methodology or underlying noise source assumptions. Requests for determination on usage of new or revised areawide data shall include the following:

(i) Maps showing old, if applicable, and new noise contours, along with brief description of data source and methodology.

(ii) Impact on existing and prospective urbanized areas and on development activity.

(iii) Impact on HUD-assisted projects currently in processing.

(iv) Impact on future HUD program activity. Where a field office has determined that immediate approval of new areawide data is necessary and warranted in limited geographic areas, the request for approval should state the circumstances warranting such approval. Actions on proposed projects shall not be undertaken while new areawide noise data are being considered for HUD use except where the proposed location is affected in the same manner under both the old and new noise data.

(b) *Site assessments.* Compliance with the standards contained in § 51.103(c) shall, where necessary, be determined using noise assessment guidelines, handbooks, technical documents and procedures issued by the Department.

(c) *Variations in site noise levels.* In many instances the noise environment will vary across a site, with portions of the site being in an Acceptable noise environment and other portions in a Normally Unacceptable noise environment. The standards in § 51.103(c) shall apply to the portions of a building or buildings used for residential purposes and for ancillary noise sensitive open spaces.

(d) *Noise measurements.* Where noise assessments result in a finding that the site is borderline or questionable, or is controversial, noise measurements may be performed. Where it is determined that noise measurements are required, such measurements will be conducted in accordance with methods and measurement criteria established by the Department. Locations for noise measurements will depend on the location of noise sensitive uses that are nearest to the predominant noise source (see § 51.103(c)).

(e) *Projections of noise exposure.* In addition to assessing existing exposure, future conditions should be projected. To the extent possible, noise exposure shall be projected to be representative of conditions that are expected to exist at a time at least 10 years beyond the date of the project or action under review.

(f) *Reduction of site noise by use of berms and/or barriers.* If it is determined by adequate analysis that a berm and/or barrier will reduce noise at a housing site, and if the barrier is existing or there are assurances that it will be in place prior to occupancy, the environmental noise analysis for the site may reflect the benefits afforded by the berm and/or barrier.

In the environmental review process under § 51.104(b), the location height and design of the berm and/or barrier shall be evaluated to determine its effectiveness, and impact on design and aesthetic quality, circulation and other environmental factors.

Appendix—definition of acoustical quantities

1. *Sound Level.* The quantity in decibels measured with an instrument satisfying requirements of American National Standard Specification for Type 1 Sound Level Meters S1.4–1971. Fast time-averaging and A-frequency weighting are to be used, unless others are specified. The sound level meter with the A-weighting is progressively less sensitive to sounds of frequency below 1,000 hertz (cycles per second), somewhat as is the ear. With fast time averaging the sound level meter responds particularly to recent sounds almost as quickly as does the ear in judging the loudness of a sound.

2. *Average Sound Level.* Average sound level, in decibels, is the level of the mean-square A-weighted sound pressure during the stated time period, with reference to the square of the standard reference sound pressure of 20 micropascals.

Day-night average sound level. abbreviated as DNL and symbolized mathematically as L_{dn} is defined as:

$$L_{dn} = 10 \log_{10}\left[\frac{1}{86400}\left(\int_{0000}^{0700} 10^{[L_A(t)+10]/10}\,dt + \int_{0700}^{2200} 10^{L_A(t)/10}\,dt + \int_{2200}^{2400} 10^{[L_A(t)+10]/10}\,dt\right)\right]$$

Time t is in seconds. so the limits shown in hours and minutes are actually interpreted in seconds. $L_A(t)$ is the time varying value of A-weighted sound level. the quantity in decibels measured by an instrument satisfying requirements of American National Standard Specification for Type 1 Sound Level Meters S1.4–1971.

3. *Loud Impulsive Sounds.* When loud impulsive sounds such as sonic booms or explosions are anticipated contributors to the noise environment at a site. the contribution to day-night average sound level produced by the loud impulsive sounds shall have 8 decibels added to it in assessing the acceptability of a site.

A loud impulsive sound is defined for the purpose of this regulation as one for which:

(i) The sound is definable as a discrete event wherein the sound level increases to a maximum and then decreases in a total time interval of approximately one second or less to the ambient background level that exists without the sound: and

(ii) The maximum sound level (obtained with slow averaging time and A-weighting of a Type 1 sound level meter whose characteristics comply with ANSI S1.4–1971) exceeds the sound level prior to the onset of the event by at least 6 decibels: and

(iii) The maximum sound level obtained with fast averaging time of a sound level meter exceeds the maximum value obtained with slow averaging time by at least 4 decibels.

Issued at Washington. D.C. on July 5. 1979.

Patricia Roberts Harris,

Secretary of Housing and Urban Development.

[FR Doc. 79–21481 Filed 7–11–79; 8:45 am]

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APPENDIX B

FEDERAL GRANT PROCEDURES FOR BUS-NOISE RETROFIT

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PREFACE

This appendix contains a description of the relevant Department of Transportation Urban Mass Transportation Administration (DOT/UMTA) grant authorities. Copies of UMTA instructions for seeking capital grants and RD&D grants are available from UMTA's Office of Public Affairs. The pamphlet, "Federal Assistance for Urban Mass Transportation," April 1979, is also very helpful. It too may be obtained from UMTA's Office of Public Affairs, U. S. Department of Transportation, Urban Mass Transportation Administration, Washington, D. C. 20590.

PROCEDURES TO BE FOLLOWED IN APPLYING FOR BUS RETROFIT GRANTS

BACKGROUND

The Tri-County Metropolitan Transportation District (Tri-Met) of Oregon has undertaken a program to develop and field-test sound attenuation kits on a representative sample of transit buses in the District's operating bus fleet. This program is sponsored by the U. S. Environmental Protection Agency (EPA) and by the Department of Transportation Urban Mass Transportation Administration (DOT/UMTA) under an UMTA research and development grant with partial EPA funding. A noise-reducing retrofit package has been developed by an acoustical consultant to Tri-Met and has been installed on a few of the buses in the fleet operating in Portland. Preliminary test results indidcate that a noise reduction of about 5 dBA was achieved by using the retrofit kit. Based on these encouraging preliminary results, Tri-Met may apply the retrofit kit to its entire fleet of transit buses.

Tri-Met estimates that the entire fleet can be retrofitted for about \$3.5 million (in 1979 dollars), based on the following breakdown of costs per bus retrofitted:

Installing turbocharged engine	\$6,000
Insulating the engine	500
Adding bellypan, plus miscellaneous modifications	500
Total cost per bus	\$7,000

Other states and localities wishing to follow Portland's lead in seeking UMTA grant money for noise abatement transit buses may find the following information helpful.

STATUS OF UMTA GRANTS PROGRAM

The following paragraphs contain a description of the relevant UMTA grant authorities.[1,2]

Section 8: Grants for mechnical Studies

This Section provides for contracts and grants to States and localities for the planning, engineering, designing and evaluation of urban mass transportation projects; for the development of regional transportation plans and for various other technical studies. These activities may include:

- Studies relating to management, operation, and economic feasibility of transit projects
- Preparation of engineering and architectural surveys, plans, and specifications
- Evaluation of previously funded projects.

These funds provide an 80% Federal share of the total project or study cost and can be used by States and localities to develop projects which could later be funded under the following sections.

---

[1] Urban Mass Transportation Act of 1964 and Related Laws, as amended through February 5, 1976, DOT/UMTA, Wash. D.C.

[2] "Federal Assistance for Urban Mass Transportation," Office or Public Affairs, DOT/UMTA, Wash. D.C., April 1979.

Section 3: Federal Financial Assistance (Capital Equipment Grants)

Section 3 of the Urban Mass Transportation Act of 1964, as amended, authorizes UMTA to make discretionary grants or loans in response to individual applications to assist States and local public agencies in financing "... the acquisition, construction, reconstruction, and improvement of (mass transit) facilities and equipment for use...in mass transportation service in urban areas..." and for coordination of these services with highway and other transportation in the area. There is $7.48 billion available for these grants from 1979 through 1983.

The legislation requires that at least $350 million annually be spent on the reconstruction and improvement of existing public transit systems and up to $200 million is allocated to Urban Initiatives projects. Urban Initiatives projects give first priority to transit projects in areas shown to be distressed. The categories of projects for UMTA Urban Initiatives funding are:

- Joint development projects to integrate public transit with housing, industrial, or commercial ventures
- Intermodal transfer -facilities for the integration of urban public transit systems with other forms of transportation
- Downtown people movers
- Transit malls, which represent a combining of traditional pedestrian malls and preferential treatment for transit vehicles on city streets.

Capital assistance grants are awarded for 80 percent of the total project costs; loans can be made up to 100 percent of total project costs. To qualify for capital grant funds under Section 3, grant applications must certify that the applicant has considered the economic and social effects of the project. In addition, grant applicants must meet administrative and statutory requirements concerning labor, civil rights, and environmental protection.

Since the passage of the Act, several urban areas have been able to modernize their transit systems considerably. UMTA has given financial assistance to State and local transit authorities in purchasing new buses, rail cars, and other capital equipment, in extending existing rapid-rail lines, in developing new rail transit systems, and in constructing new bus garages. Nearly all of the Section 3 funds are distributed by UMTA headquarters. If allocated monies are not obligated by the end of the fiscal year, they must be returned to the Treasury. If they are obligated, there is no time limit on their use. However, UMTA retains the authority to recall the money at any time.

Section 5: Urban Mass Transit Program (Formula Grants)

The funds allocated to this Section are apportioned to urbanized areas in four tiers. The first tier is apportioned to all urbanized areas by a specified formula based on population and population density. The second tier is also apportioned by population and population density, but with 85% of the funds going to areas with a population over 450,000. The third tier funds are for commuter rail fixed-guideway transit. The fourth tier funds are for capital grants for the purchase of buses and bus-related equipment and facilities. Until 1980, these funds will be apportioned by a population and population density formula. The Department of Transportation will study alternative approaches to the fourth tier funding and will report to Congress by January 1, 1980. The formula assistance funds may be used for:

- Acquisition, construction, and improvement of facilities and equipment for use in mass transportation service
- Payment of operating expenses to improve or to continue such service.

Section 5 funds are distributed by the ten regional UMTA offices. Each region prepares a program plan denoted Transportation Implementation Program (TIP) covering a five-year period. Funds are allocated according to priorities in the TIP. In each state, the governor names an agency to receive and dispense the apportioned funds for urbanized areas of more than 200,000 population; the governor dispenses the funds directly to smaller urbanized areas. The Federal grant for any construction project under this Section may not exceed 80 percent of the cost of the project. In comparison, the Federal grant for operating assistance may not exceed 50 percent of the deficit. Formula funds, if obligated but not used within three years, may be recalled and reallocated. However, this occurs very rarely.

Grant authority under Section 6 of the Urban Mass Transportation Act is described here as well. It is the section governing the present Tri-Met grant.

Section 6: Research, Development, and Demonstration Projects

Funds may be provided by grant or contract for research, development' and demonstration projects in all phases of urban mass transportation, which will assist in:

- The reduction of urban transportation needs
- The improvement of mass transportation service
- The contribution of mass transportation service toward meeting total urban transportation needs at a minimum cost.

UMTA headquarters in Washington appropriates most of the discretionary funds under Section 3 and the RD&D grands under Section 6. However, the regional authorities collectively have somewhat more funds to dispense under Section 5 formula grants.

The Interstate Substitutions became possible under the Federal Aid Highway Act of 1973. This allows highway trust funds to be used for mass transportation facilities and equipment. The two programs of assistance under this Act are the Federal Aid Urban Systems (FAUS) funds and Interstate Highway Substitutions (IHS).

FAUS funds are apportioned to the states by a formula based on population. They can be used to support either mass transportation projects or urban highway network projects in urbanized capital areas over 200,000 population. Local officials can propose to substitute a transit project for an urban highway project. If approved by the U. S. Secretary of Transportation, the transit project will receive 75% Federal funding.

Interstate highway funds are available for transit construction and acquisition. Substitution of non-highway public mass transit facilities and/or equipment for a previously approved portion of the Interstate highway system within urban areas may occur with approval of the U. S. Secretary of Transportation. If approved, the Federal government will pay 85% of the total cost of the transit project--not to exceed the cost of the deleted Interstate segment.

H.R. 4440 is a bill in the House of Representatives making appropriations for the Department of Transportation for the fiscal year ending September 30, 1980. It carries the following relevant provisions:

RESEARCH, DEVELOPMENT, AND DEMONSTRATIONS AND UNIVERSITY RESEARCH AND TRAINING

For necessary expenses for research and training, as authorized by the Urban Mass Transportation Act of 1964, as amended (49 U.S.C. 1601 et seq.), to remain available until expended; $63,500,000: Provided, That $61,000,000 shall be available for research, development, and demonstrations, $2,000,000 shall be available for university research and training and not to exceed $500,000 shall be available for manageerial training as authorized under the authority of said Act.

URBAN DISCRETIONARY GRANTS
(INCLUDING TRANSFER OF FUNDS)

For necessary expenses for urban discretionary grants as authorized by the Urban Mass Transportation Act of 1964, as amended (49 U.S.C. 1601 et seq.) to remain available until September 30, 1983; $1,28,000,000, of which $9,925,000 shall be derived by transfer from the Urban Mass Transportation Fund: Provided, That none of these funds shall be available to retrofit any existing fixed rail transit system to comply with regulations issued pursuant to section 504 of the Rehabilitation Act of 1973.

RURAL AND SMALL URBAN GRANTS

For necessary expenses for public transportation projects in areas other than urbanized areas as defined for the purposes of the Urban Mass Transportation Act of 1964, as amended (49 U. S.C. 1601 et seq.), $75,000,000 to remain available until expended.

URBAN FORMULA GRANTS

For necessary expenses for urban formula grants as authorized by the Urban Mass Transportation Act of 1964, as amended (49U.S.C. 1601 et seq.), $650,000,000, to remain available until expended.

WATERBORNE TRANSPORTATION DEMONSTRATION PROJECT

For necessary expenses for a waterborne transportation demonstration prject as authorized by Section 320 of the Surface Transportation Assistance Act of 1978 (Public Law 95-599); $10,000,000, to remain available until September 30, 1981.

INTERSTATE TRANSFER GRANTS
(INCLUDING RESCISSION)

For necessary expenses to carry out the provisions of 23 U.S.C. 103(e)(4) for fiscal year 1980, $700,000,000, to remain available until expended; and for fiscal year 1981, $425,000,000, to remain available until expended: Provided, That amounts for highway projects substituted for Interstate System segments shall be transferred to the Federal Highway Administration: Provided further, That $713,100,000 of contract authority made available or authorized for Interstate transfer grants is hereby rescinded.

The hearings of the House of Representatives Committee on appropriations concerning Department of Transportation and Related Agencies Appropriations for 1980 also have some relevant material regarding UMTA grants.

Some of the relevant points made in UMTA's FY 1980 budget estimates submission are given here.

- Under the new legislation a greater emphasis is placed upon the use of the Section 5 program for the funding of capital grants, particularly, routine capital assistance for bus and bus-related projects.

- Under the UMTA program, bus and bus related projects are eligable for funding under the Sections 3, 5, and 18 grant programs. They are also eligible under the Interstate transfer and Federal-Aid Urban System programs. Requirements uner new legislation call for an urbanized area to demonstrate that bus and bus facility requests cannot be reasonable accommodated through Sections 5 (a)(4) (apportionments before assistance for the cost of all or part of such projects may be made available under the Section 3 program. Bus projects in non-urbanized areas (under 50,000 population) are intended to be funded primarily under the Section 18 program (Activity IV). For FY's 1979 and 1980, bus projects which cannot be accommodated through State apportionments under the Section 18 program will be considered for funding under the Section 3 program. After FY 1980, such projects will be expected to be funded under the Seciton 18 program.

- UMTA estimates that $235 million and $305 million in; Section 3 discretionary resources will be used together with resources available under the other grant programs mentioned above during FY's 1980 and 1981, respspectively to accommodate a variety of bus captal improvements. Section 3 funds will contribute towards the replacement of many overage vehicles which are no longer cost effective to operate, and for the purchase of related support equipment such as radios, passenger shelters, bus stop signs, spare engines etc. UMTA believes that these funds are necessary to supplement funds available under the Section 5 formula apportionment program for bus and bus projects. Under the Section 5 program, funds for bus capital projects are apportioned to urbanized areas on the basis of population and population density. However, the use of these apportionment factors does not necessarily reflect the need for new or replacement behicles in an urbanized area, or the need for related support facilities.

- The new legislation mandates that UMTA carry out a study of alternative methods of apportioning funds for the purchase of buses and related equipment and the construction of bus related facilities. To accomplish this, UMTA has issued a public notice requesting data from each urbanized area relating to the characteristics and operations of their bus fleets. This study will be submitted to Congress by January 1, 1980, together with recommendations for legislative changes.

- There are more than 50,000 bus transit vehicles currently owned or operated under contract by public transit agencies. Of this amount 11,900 are 15 years or older. Many of these buses will be in need of replacement in order to maintain economical, efficient, and comfortable bus transit service in FY's 1980 and 1981. UMTA will attempt to accommodate within the overall program level the replacement of as many of the overage bus vehicles which are in revenue service as possible. However, the replacement of obsolete vehicles will continue to be staged over a multi-year period and will receive funding to the extent possible in conjunction with other pressing demands on the Section 3 program.

- UMTA expects to be asked to act on proposals from other cities to implement major improvements to bus service over a multi-year time period. UMTA encourages such cost-effective proposals, especially where they prove more effective than fixed guideway investments. A portion of the FY 1981 Section 3 bus planning level is based upon funding for Certain major bus projects.

TABLE 4 (from the hearings)
BUDGET CATEGORY A - BUS AND PARATRANSIT SYSYSTEMS
BY 1980 PROGRAM FOR $3 AND $5 RESOURCES
(dollars in millions)

	Section 3	Section 5	Total
- Standard transit vehicle replacement (2,700 vehicles........	$ 55	$ 190	$ 245
- Standard transit vehicle fleet expansions (270 vehicles.....	5	20	25
- Construction of facilities.........	85	30	115
- Support equipment..................	15	30	45
- Paratransit vehicles (2,500 vehicles..........................	25	30	55
- Major commitments..................	50	-0-	50
	$ 235	$ 300	$ 535

APPENDIX C

SERVICE BULLETIN FOR RETROFIT OF NOISE REDUCTION MODIFICATIONS FOR FLXIBLE TRANSIT BUS

REPORT NO. UMTA-OR-06-0005-80-1

NOISE REDUCTION RETROFIT FOR A "NEW LOOK" FLXIBLE® TRANSIT BUS
Service Bulletin

Michael C. Kaye

TRI-COUNTY METROPOLITAN TRANSPORTATION
DISTRICT OF OREGON
4012 S.E. Seventeenth Avenue
Portland OR 97202

SEPTEMBER 1980

FINAL REPORT

DOCUMENT IS AVAILABLE TO THE PUBLIC
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Prepared for

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URBAN MASS TRANSPORTATION ADMINISTRATION
Office of Technology Development and Deployment
Washington DC 20590

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF NOISE ABATEMENT AND CONTROL
Technology and Federal Programs Division
Washington DC 20460

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16. Abstract

Baseline bus configuration, noise ratings, and performance benchmarks are presented for a Flxible® 111DC-D061 transit bus powered by a Detroit Diesel 8V-71N engine. Instructions are given as to how the engine is retrofitted with a turbocharger and ancillary hardware. The engine aspiration system is revised for freer breathing. The engine compartment is lined with an anti-noise blanket. The radiator grille is enlarged. The compressed air system dryer hiss is silenced. The instructions are complete with sources for manufactured components and raw materials and with mechanical drawings for components to be locally fabricated. Illustrations and text direct installation. Effects of noise ratings and performance side-effects are given. Practical application is coupled with theoretical explanation throughout.

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*Under contract to:
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PREFACE

This document is an instruction: how to apply a noise treatment to a contemporary city transit bus without extensive structural alteration. Specifically addressed is the Flxible® Model 111DC-D061 with a Detroit Diesel 8V-71N engine; however, the concepts and much of the hardware described here are transferable to similar buses.

The information is of interest primarily to transit bus operators wanting to reduce noise by practical means, and to government agencies, manufacturers, and planners concerned with reducing the noise of buses in service at a moderate cost.

Acoustic benefits and performance side-effects are given. One beneficial side-effect (because of turbocharging) is reduced harmful exhaust emissions. Another, because of smaller injectors and reduced exhaust back pressure, is fuel conservation.

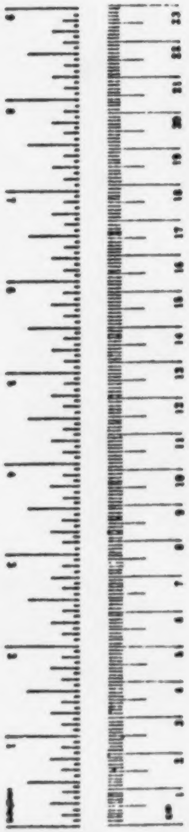
Acknowledgment is made of the special contributions made by Gary Brentano and Richard Woods of the Tri-County Metropolitan Transportation District of Oregon (Tri-Met) who managed the project.

The work has been directed by the U.S. Department of Transportation: James Campbell for the Urban Mass Transportation Administration and Robert L. Mason for the Transportation Systems Center.

METRIC CONVERSION FACTORS

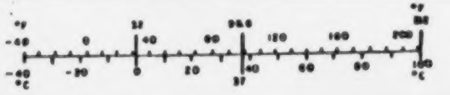
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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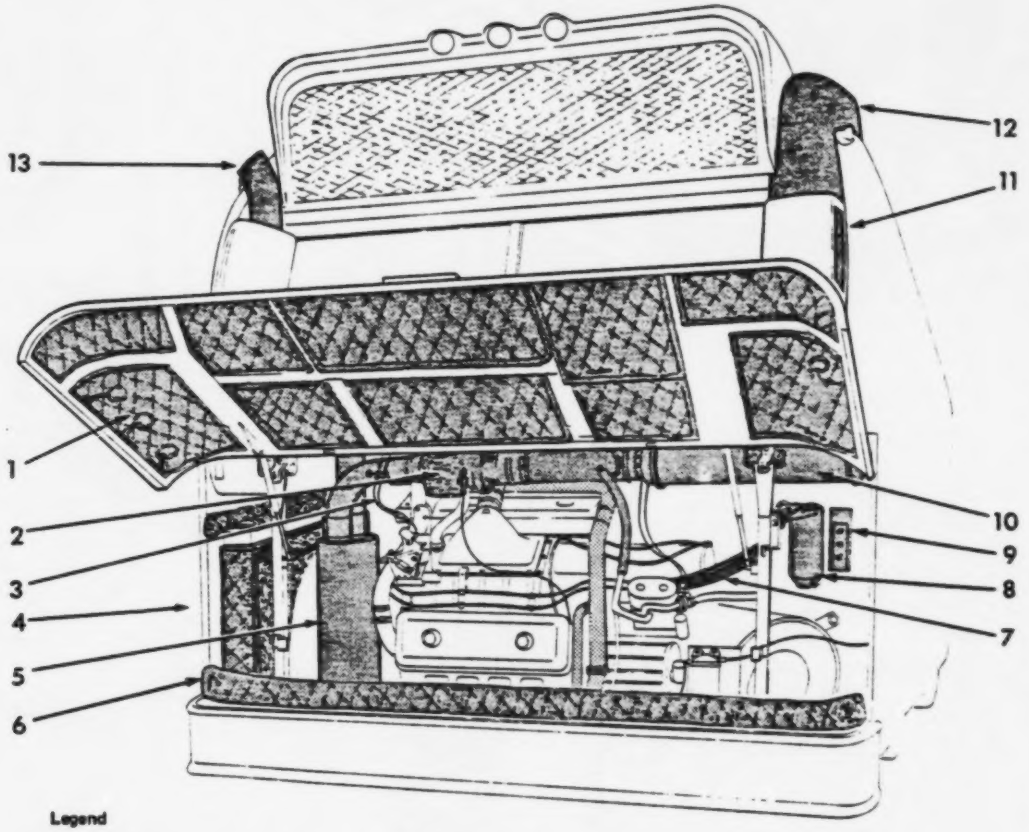
INTRODUCTION

Owing to the general rise in prices for new vehicles, an operator might choose to extend the life of existing buses by renovation and remodeling instead of purchasing modern replacements. Noise treatments might well be included in such a program. Since fleets ordinarily consist of look-alikes having many small differences, this Instruction is designed to be of greatest utility by thoroughly documenting one good way to treat a typical bus. Highlights of the treatment are depicted in Figure 1. With this information, an experienced person can adapt the treatment to other bus models and expect similar results.

This approach unavoidably entails being specific about one set of suppliers and tradenames. There are a number of other products of equivalent quality and effectiveness. Regrettably, they cannot all be mentioned.



Legend

1 Engine compartment padding
2 Jacketed turbocharger
3 Air dryer line
4 Enlarged grille
5 Jacketed muffler, relocated
6 Door stop
7 Relocated fuel lines
8 Relocated fuel filters, removed bypass oil filter
9 Relocated switch box
10 Larger air cleaner
11 Blanked inlet
12 Snorkle
13 5" exhaust stack

FIGURE 1
NOISE TREATED BUS

This, then, is an instruction for applying a noise treatment to a Flxible® Model 111DC-D061 contemporary transit bus powered by a Detroit Diesel 8V-71N engine. Basically, the engine is retrofitted with a turbocharger, requiring new intake and exhaust systems, and the engine compartment is lined with anti-noise padding. There are no major structural alterations or seriously adverse side-effects. The intent is to make these changes when the engine is due for an overhaul and will be dismounted.

BASELINE CONFIGURATION

The engineering work that led to this Instruction was done by Tri-Met in Portland, Oregon. Table 1 lists the important characteristics of the bus before it was modified.

TABLE 1.
BASELINE BUS CHARACTERISTICS

Coach Make	Flxible
Coach Model	111DC-D061
Built	October, 1972
Engine Make	Detroit Diesel 8V-71N
Engine Model	7087-4523 City transit type 43° layover clockwise rotation as viewed from flywheel
Injectors	71C5
Fuel	#1 Diesel
Transmission	Allison VS2-8
Length	35' 8"
Width	102"
Seats	42
Weight	22,560 lbs.
Axle Ratio	6 1/7 : 1
Tires	Firestone 12.5 x 22.5 bias ply, 100 psi.
Air Conditioner	Roof-mounted condenser
Exhaust System	4" tubing with EIP Aspirator
Muffler	Nelson T-120323-F
Air Cleaner	Donaldson EBA 13-0026
Pre-separator	Donaldson PVH 000885
Fan	Schwitzer L71 911024 (28" dia, 8-blades)
Radiator Core	1,048 in^2, 11 fins/inch, 222 tubes in 4 rows
Shroud	30" dia, sheet metal
Fan Drive	GMC Torus
Engine Speed at Stall	1,250 rpm
1st Upshift Engine Speed	1,800 rpm at full throttle
1st Upshift Road Speed	22 mph

PRELIMINARY FIXES

Tri-Met's buses are relatively quiet to begin with when compared to those of many other transit systems. Other operators may be able to bring their bus noise down by doing what Tri-Met has already done and by paying attention to critical repair items.

1. Derate the engine by using the *smallest available injectors:* 71C5 (equivalent to 50 mm). This will reduce full throttle engine and exhaust noise. It is not practical to reduce noise by downsetting the overspeed governor. The transmission automatically upshifts before the engine speed exceeds 1,800 rpm. Downsets to lesser speeds would overly inhibit the bus's performance. Tri-Met uses small injectors and #1 Diesel to reduce exhaust smoke. Diesel #1 can slightly reduce full throttle engine and exhaust noise since it has about 4% less heat value per gallon.

2. Have a *modulated speed fan drive* such as the standard GMC Torus hydraulic clutch or the Schwitzer Viscous clutch. This minimizes average fan noise. An on-off fan clutch is not as satisfactory, but is better than a fixed drive. Tri-Met uses automatic fan drives for improved fuel economy.

3. Prevent unnecessary exhaust noise by making sure there are no *exhaust leaks* between the engine and the muffler outlet and that the *muffler is adequate.* Joints frequently break open because there is extensive stress caused by intermotion between the engine and the muffler. Provide an intermediate flexible tube section to relieve stress.

4. Keep the air side of the *radiator core clean.* Make sure the lower part of the *fan shroud is not left off.* Keep the *fan centered in the shroud.* These items minimize average fan speed, and thus fan noise, where there is an automatic fan drive. Also, the parasitic fan load on the engine is lessened, releasing more power to the wheels and reducing fuel consumption.

5. Adjust the transmission first *upshift speed to the low end* of its range: 22 mph. This reduces peak overall noise.

6. Keep *bellypans* in place. To reduce maintenance cost, Tri-Met does not use these optional engine compartment floors. However, operators who choose to use them can expect reduced engine noise generally and reduced fan noise on the right side. Although louvered sheet metal bellypans are not as acoustically effective as they could be, they are of some benefit.

7. Replace the 3 sets of synthetic *rubber engine mounts* when they fail, especially the donut-shaped mounts where the engine cradle connects to the chassis. If this is not done, engine vibration will telegraph more strongly into the bus body and the fan will move off-center in the shroud.

8. Repair *body rattles.* Keep in good working order the various handles and hold-downs to compartment doors. Tri-Met favors the spring-loaded struts that facilitate the opening and closing of the rear engine compartment door.

TURBOCHARGER CONVERSION

A turbocharger will reduce both engine noise and exhaust noise. Engine noise is reduced due to softening of the abrupt increase in the rate of cylinder pressure rise at the onset of ignition during the compression stroke. Exhaust noise is reduced since the drive turbine reflects and scatters the impinging sound waves.

The original motivation behind supercharging engines by means of an exhaust turbine (turbocharger) was to increase power output without increasing engine size. (The 8V-71TAC is rated as high as 350 hp with 75 mm injectors.) Figure 1 shows a turbocharged 8V-71 city coach engine. Turbocharging also compensates for rarified air at higher altitudes.

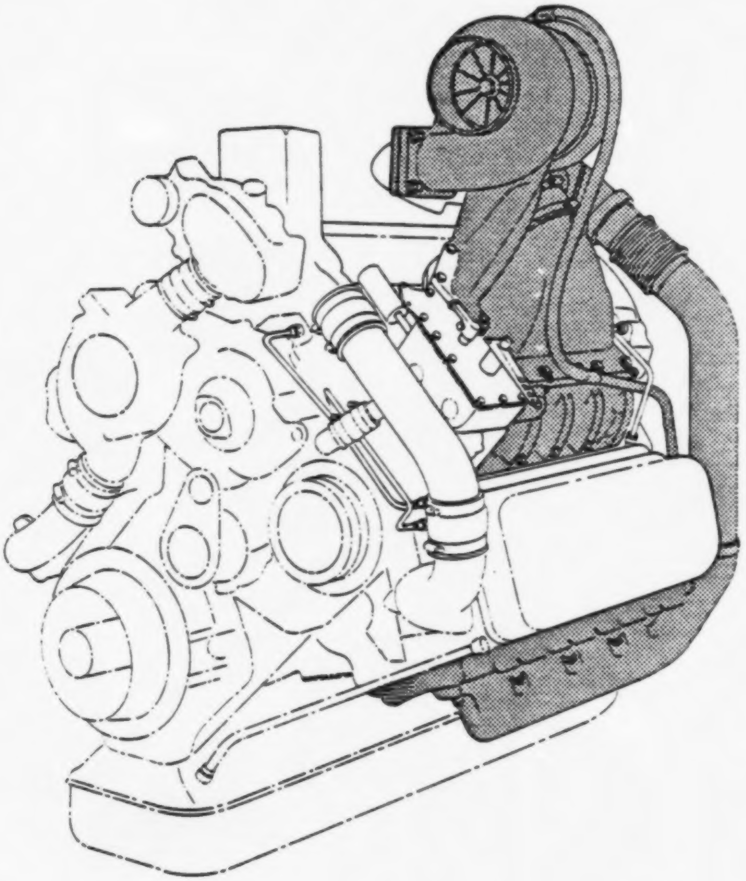


FIGURE 2.

TURBOCHARGED DETROIT DIESEL CITY COACH 8V-71

The turbocharger captures escaping energy from the exhaust pipe and returns it to the engine in the form of denser intake air. This enables more fuel to be burned and thereby more power to be produced.

The effect can be intensified with an "aftercooler" which cools the compressed intake air, making it even more dense. An aftercooler retrofit was not attempted. Making room for the aftercooler in the vee of the block requires more engine modification than it is worth.

Turbocharging reduces harmful gaseous exhaust emissions and can slightly improve fuel efficiency. Practically all diesel engines manufactured in the U.S. will be turbocharged in the future to satisfy clean air regulations.

Although turbocharging provides more air, thus allowing more fuel to be burned, it is inconsistent with noise control to increase fuel input along with a turbocharger retrofit. Consequently, injector size is kept the same or reduced if possible.

To plan a turbocharger conversion, the bus operator should review the information in Table 2 with his local engine dealer.

TABLE 2.

COMPARISON OF KEY ENGINE HARDWARE
WHEN CONVERTING AN 8V-71N INTO AN 8V-71T

Item	8V-71N	8V-71T
[1] Engine Model	7087-4523	[2] 7087-4620 Modified
[3] Compression Ratio	18.7 : 1	17 : 1
[4] Cylinder Kit	Naturally Aspirated City Coach Engine	Automotive Turbocharged with Crosshead Piston
Valves & Valve Inserts	Inconel X	[5] Nimonic 90
[6] Blower Drive Ratio	2.05 : 1	1.95 : 1
[7] Blower Seals	Lip	Ring
[8] Throttle Delay	.454"	.345"
Injectors	71C5	71C5
[8] Injector Timing	1.484"	1.496"
[9] Turbocharger	None	TV-8101 5101513 A/R 1.60
Exhaust Manifold, Crossover Pipes, and Blower Inlet	N Type	Turbo Type

Notes to Table 2

[1] These model numbers apply to a Flxible® city coach with a 43° layover.

[2] Model 7087-4620 applies to an 8V-71TAC which comes with an aftercooler. We are deleting the aftercooler. There is no model designation for a city coach 8V-71T (turbocharged without aftercooler).

[3] Compression ratio is reduced to prevent overstressing the engine since the manufacturer anticipates more fuel, more cylinder pressure (BMEP), and more power. We are not adding more fuel and taking more power, but we change the pistons anyway because their improvements, including their improved piston rings, will extend engine life.

[4] Since we do not use an aftercooler, we can use the same design N-engine cylinder liners which have shorter intake port slots.

[5] Built to withstand higher temperatures of turbocharged engines.

[6] Scavenging blower is slowed to the minimum to save parasitic power loss. The blower is still needed to purge spent gases of combustion during situations when the turbocharger is lagging and not up to speed.

[7] Improved seal needed to withstand higher air box pressures.

[8] Reducing compression ratio tends to make the engine harder to start. Compensating adjustment is made to injector timing. If hard starting is still a problem in adverse weather, an ether cup installed on the dirty side of the air cleaner is recommended. With turbocharging, there is a tendency for a puff of smoke to occur at the onset of full throttle acceleration. Adjustment of the throttle delay corrects this.

[9] Tri-Met chose the TV-7101 (A/R = 1.23) turbocharger, Part Number 510509 which is designed for the 1978 8V-71TAC "California" engine. This is a more "active" turbo. Since we wanted significant supercharging at our customary low power levels, we selected this optional model. The TV-8101 is usually supplied with an 8V-71T, but is better matched with the highway truck application where engine load is higher.

The engine should have die-cast aluminum valve covers and a block-mounted crankcase breather pad.

Table 3 lists the changes in engine operating characteristics caused by turbocharger conversion.

After the engine is reassembled and checked for proper operation, check the turbocharger's functioning by measuring the pressure in the air box while the engine is under full throttle. Rather than rely on the idiosyncrasies of a chassis dynamometer, a simple, repeatable test is to drive the bus up a steady grade at full throttle, accelerating slowly, and note the air box pressure 100 rpm before top speed is reached. Pressures up to 50 inches of mercury can be expected. This baseline reading can be used later for verification if the turbocharger's performance is suspected of having fallen off.

With turbochargers, one must guard against any exhaust gas leakage past manifold gaskets, joints, or through cracks in the exhaust system upstream from the power turbine. This will weaken their propulsion. Also, it is important not to let air cleaner filter elements load up with dirt past the allowable restriction limits.

TABLE 3.

CHANGES TO ENGINE OPERATION DUE TO TURBOCHARGER CONVERSION

(Relevant to 2,000 rpm, full throttle, and #1 Diesel)

Item		Units	8V-71N	8V-71T
[1] Allowable exhaust back pressure		"Hg	6	3
[1] Allowable intake restriction		"H_2O	25	20
[2] Air Flow		CFM	830	1,030
[3] Water Flow		GPM	123	123
[4] Heat Rejection to Coolant		BTU/min	6,322	7,040
[5] Output		BHP	218	220
[6] Fuel Efficiency		lbs/BHP-hr	.394	.402
Peak Torque		ft-lbs	660	740
		rpm	1,200	1,200
Exhaust emissions	NO_2	PPM	1,150	980
	HC	PPM	153	111
	CO	PPM	140	154

---

[1] Sensitivity of turbocharger to aspiration restriction is reflected in more stringent limits set by the engine manufacturer.

[2] Reflects supercharging effect of turbocharger.

[3] No change to water pump.

[4] Heavier load on cooling system due to higher cylinder temperatures.

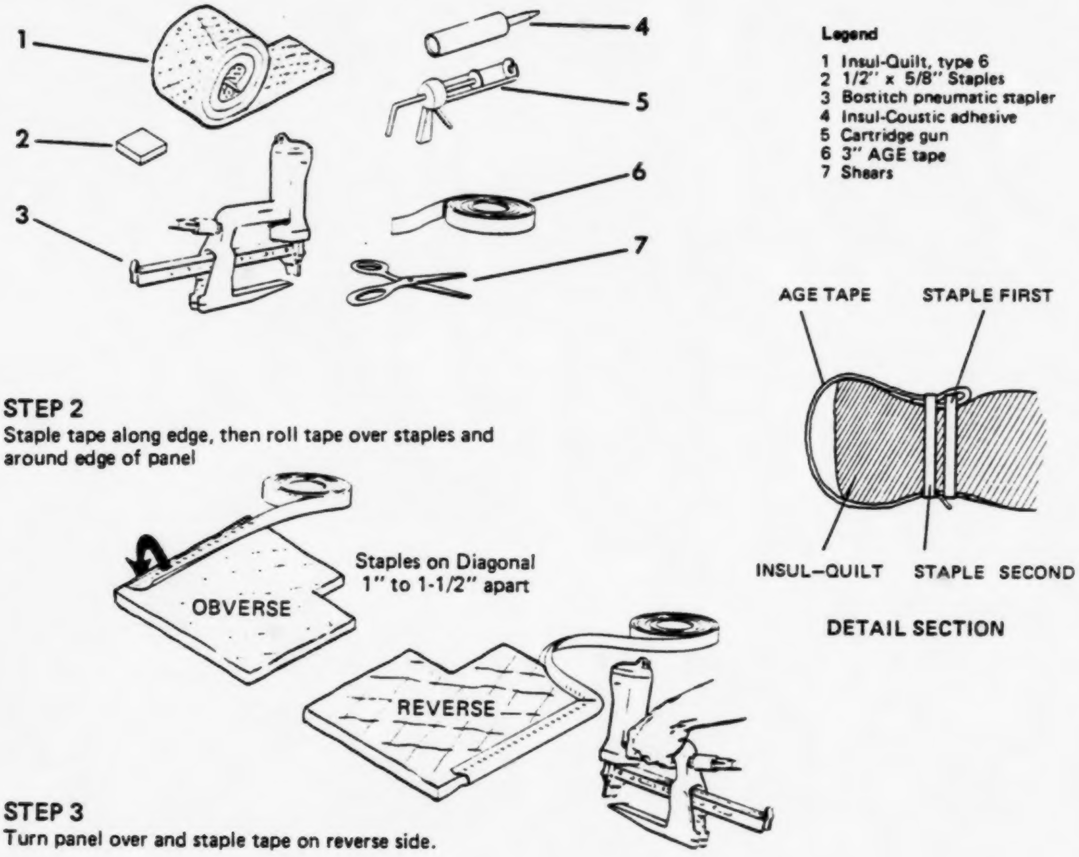
[5] Same injectors, same fuel, same horsepower at rated speed.

[6] No significant change to BSFC when converting an 8V-71N to an 8V-71T, but state-of-the art turbocharged diesels do have improved fuel efficiency.

ENGINE COMPARTMENT PADDING

The engine compartment is padded with a 1¼ inch thick material that is soft, rugged, and easily bent. It consists of a 10 oz/ft^2 lead septum sandwiched between two blankets of glass fiber. The composite is protected by a lightweight waterproof aluminized glass cloth. The lead serves as a sound barrier and the glass fiber blankets reduce echoing. It can be steamcleaned and is incombustible.

After cutting to size with ordinary hand shears (die cut in mass production), the fabricator binds the edges by stapling on an aluminized glass cloth edging tape (AGE) as shown in Figure 3. The pads can be held in place with mechanical fasteners, but we use a quick-drying adhesive especially compounded for the purpose.


STEP 1

Gather tools, materials, and cut panels to size

Legend

1 Insul-Quilt, type 6
2 1/2" x 5/8" Staples
3 Bostitch pneumatic stapler
4 Insul-Coustic adhesive
5 Cartridge gun
6 3" AGE tape
7 Shears

STEP 2

Staple tape along edge, then roll tape over staples and around edge of panel

STEP 3

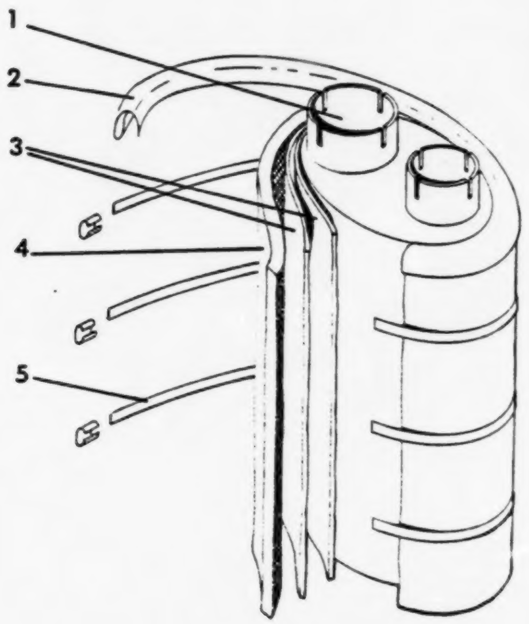
Turn panel over and staple tape on reverse side.

1
2
3
4
5
6
7
Staples on Diagonal
1" to 1-1/2" apart
OBVERSE
REVERSE
AGE TAPE
STAPLE FIRST
INSUL–QUILT
STAPLE SECOND
DETAIL SECTION

FIGURE 3
ANTI–NOISE PADDING FABRICATION TECHNIQUE

The padding is placed on all flat areas or single curvature surfaces that are not subject to removal for routine service operations.

Figure 4 illustrates the muffler jacket. It is lined with two layers of ceramic cloth for thermal protection and held in place with ½" wide steel bands applied by the strapping apparatus ordinarily found in Shipping Departments. This jacket stops muffler shell noise, reduces echoing of fan and engine noise, and protects maintenance personnel from accidental burns.



Legend

1 10" x 15" Oval Muffler
2 Edging Taper
3 Two Layers Ceramic Cloth Lining 26" x 44"
4 26" x 44" anti-noise pad
5 1/2" Steel Strap

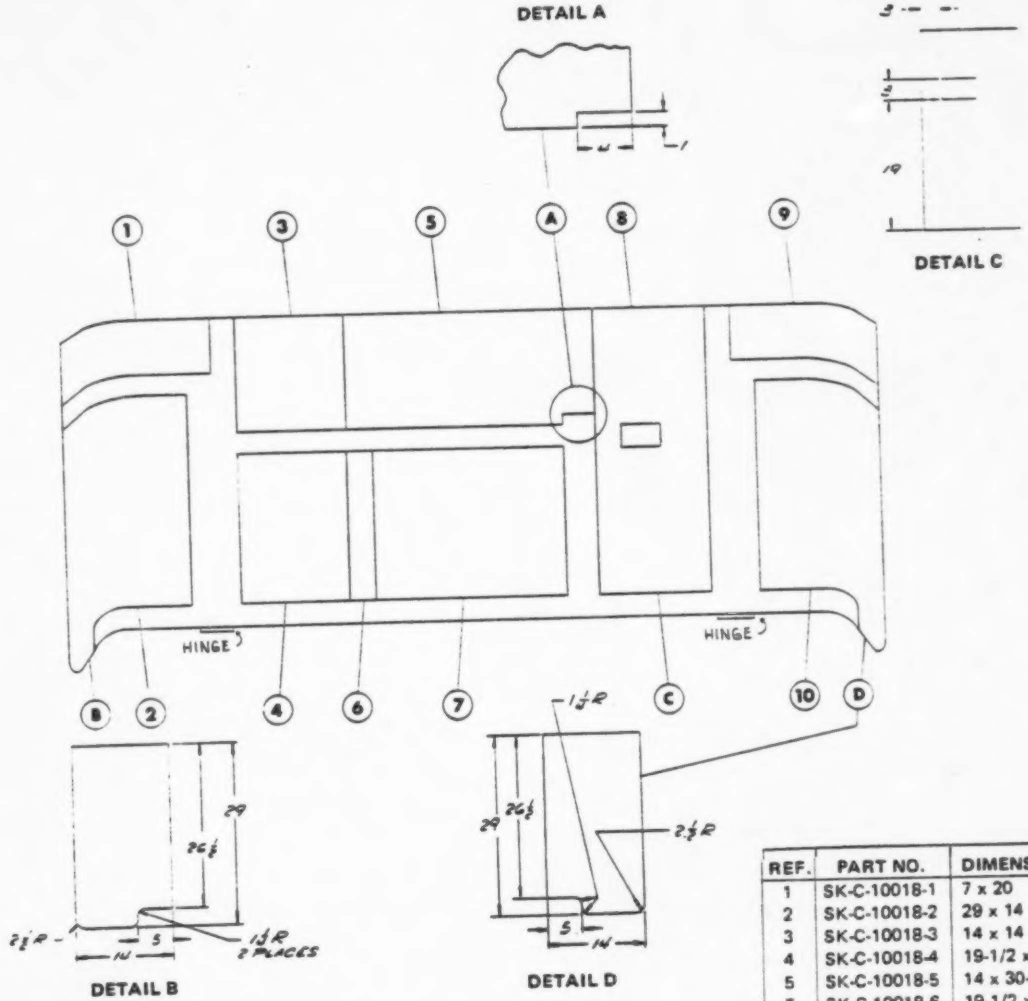
REFER TO DWG: SK-A-10003A

FIGURE 4.
MUFFLER JACKET

Figure 5 dimensions and locates the ten anti-noise pads that fit into the recesses of the rear door to the engine compartment. A single large pad would be simpler, but there is insufficient room between the high spots on the door and the high spots on the engine. Chafing would penetrate and harm the pad.

Before gluing pads to the door, remove lamp holders and attach crimped screw holders to the screw holes in the door. Lamps can thereafter be removed and serviced from the outer side of the door without requiring access to the nuts on the inside. Cut holes in the pads to let wiring run to lamps.

To seal the upper edge and right and left sides of the rear door, 1 3/8" OD sponge rubber tubing is split in half and glued flat side down to the niche in the door's edges.


DETAIL A
DETAIL C
19
①
③
⑤
Ⓐ
⑧
⑨
HINGE
HINGE
Ⓑ
②
④
⑥
⑦
Ⓒ
⑩
Ⓓ
29
26½
2½R
5
14
1½R 2 PLACES
DETAIL B
1½R
2½R
DETAIL D

REF.	PART NO.	DIMENSIONS
1	SK-C-10018-1	7 x 20
2	SK-C-10018-2	29 x 14
3	SK-C-10018-3	14 x 14
4	SK-C-10018-4	19-1/2 x 14
5	SK-C-10018-5	14 x 30-3/4
6	SK-C-10018-6	19-1/2 x 3
7	SK-C-10018-7	19-1/2 x 24
8	SK-C-10018-8	35 x 13-1/2
9	SK-C-10018-9	7 x 20
10	SK-C-10018-10	29 x 14

REFER TO DWG: SK-C-10018-A

FIGURE 5.
REAR DOOR PADDING

To seal the lower edge of the rear door, a door stop is fastened to the bumper so that it just touches the door padding when the door is fully closed. Figure 6 shows how an anti-noise pad is folded over a 4-piece aluminum angle, forming a seal with the door padding to reduce escaping noise.

REFER TO DWG: SK-C-10019-A

REF.	PART NO.	DESCRIPTION
1	SK-C-10019-3	9" x 105"
2	SK-C-10019-1	Corner
3	SK-C-10019-2	Straight

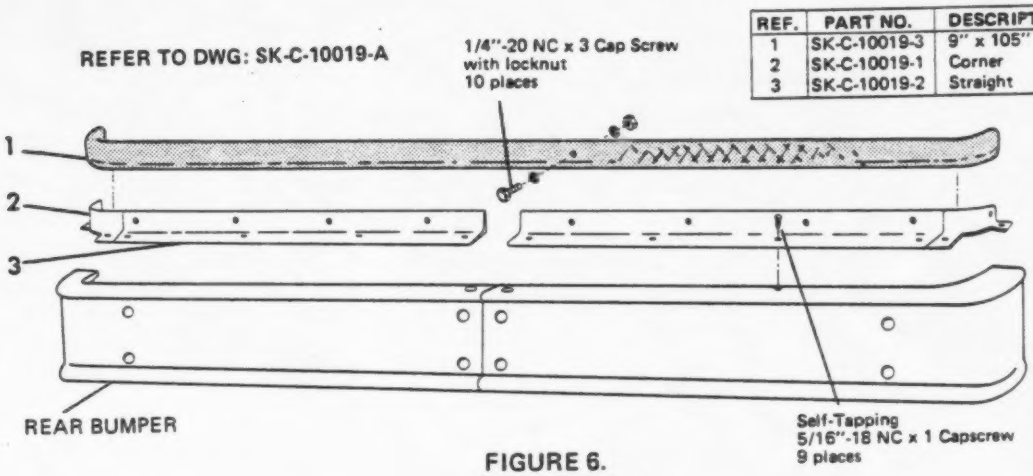
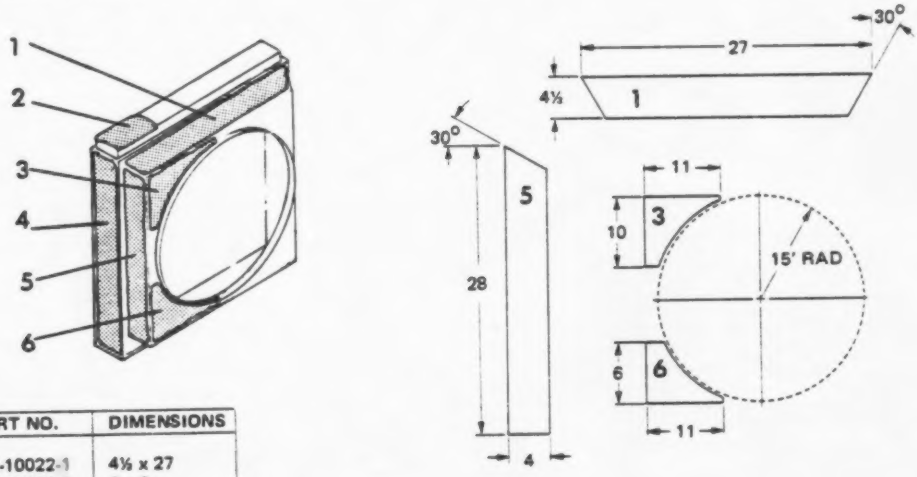

1/4"-20 NC x 3 Cap Screw
with locknut
10 places
1
2
3
REAR BUMPER
Self-Tapping
5/16"-18 NC x 1 Capscrew
9 places

FIGURE 6.
DOOR STOP

Figure 7 dimensions and locates the six pads that are glued to the radiator and shroud assembly.


1
2
3
4
5
6
27
30°
4½
1
30°
5
28
4
11
3
10
15' RAD
6
6
11

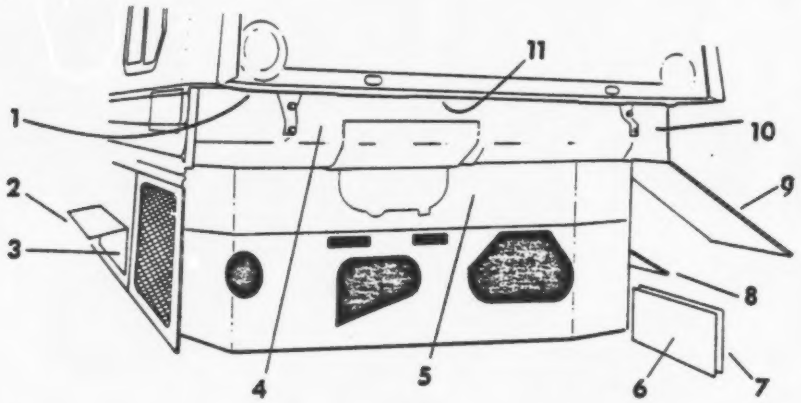
REF.	PART NO.	DIMENSIONS
1	SK-B-10022-1	4½ x 27
2	SK-B-10022-2	6 x 9
3	SK-B-10022-3	10 x 22
4	SK-B-10022-4	6 x 26
5	SK-B-10022-5	4 x 28
6	SK-B-10022-6	6 x 11

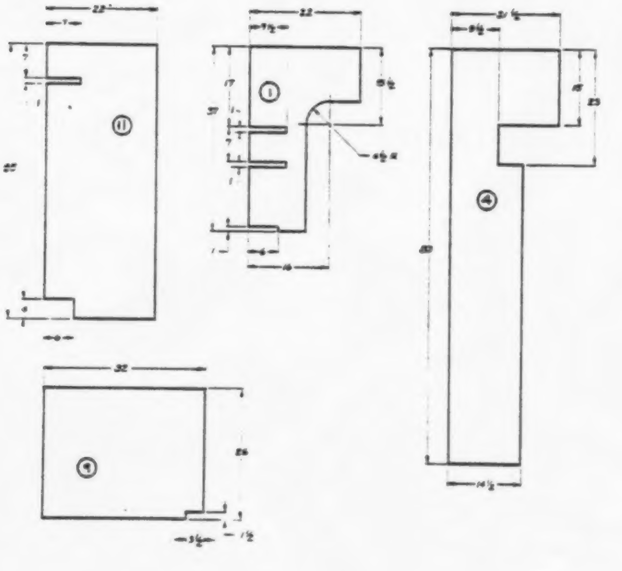
REFER TO DWG: SK-C-10022A

FIGURE 7.
RADIATOR INSUL–QUILT TREATMENT

Anti-noise pads are put on the overhead and on the firewall of the engine compartment. The numerous mounting brackets, wire harness clips, and hose clamps are detached from these surfaces and reattached over the pads. These pads are depicted on Figure 8 along with the pads that attach to the right side of the engine compartment.

Finally, anti-noise pads are installed in the air conditioner compressor compartment on the left side of the bus and in the circuit breaker compartment on the right side just ahead of the engine compartment. Both door pads are glued in place. The compressor compartment floor is simply laid down.





REF.	INSUL-QUILT PAD	DIMENSIONS
1	Overhead Left	See Detail
2	Compressor Door	13½ x 24
3	Compressor Floor	22 x 32
4	Rear Wall	See Detail
5	Firewall	14 x 63
6	Lower Right	14 x 31
7	Aluminum Backing Plate	14 x 33
8	Electrical Compt Door	13½ x 31½
9	Right Hand Door	See Detail
10	Upper Right	11 x 13
11	Overhead Right	See Detail

REFER TO DWG: SK-C-10021A

FIGURE 8.
FIREWALL, ETC. PADDING

AIR INTAKE SYSTEM

A new air intake system is installed because the turbocharger displaces the original air cleaner and because the engine both draws in more air and is more sensitive to air intake restriction (Table 3). The main changes are:

	Before	After
Air Cleaner	Donaldson EBA 13-0024	Donaldson ECG 11-2000
Pre-cleaner	Donaldson PVH 000885	Removed
Inlet	Rear window cowl	Rooftop snorkle

The turbocharger requires that the air filter element must be serviced when intake restriction reaches 20 "H_2O. If not, exhaust emissions will become unduly polluted.

The pre-cleaner is removed due to lack of space.

To compensate for the tendency toward shorter air filter service interval caused by the more demanding engine and the loss of the pre-cleaner, a larger air cleaner (80% more filter paper area) is used and the air is taken in from a cleaner source atop the bus roof facing forward.

The existing air intake system is removed and replaced with the system shown in Figure 9. The new filter element is easier to remove and replace. The rubber reducing elbow is protected from the hot exhaust pipes forming a wye before entering the turbocharger by insulating jackets covering the pipe elbows.

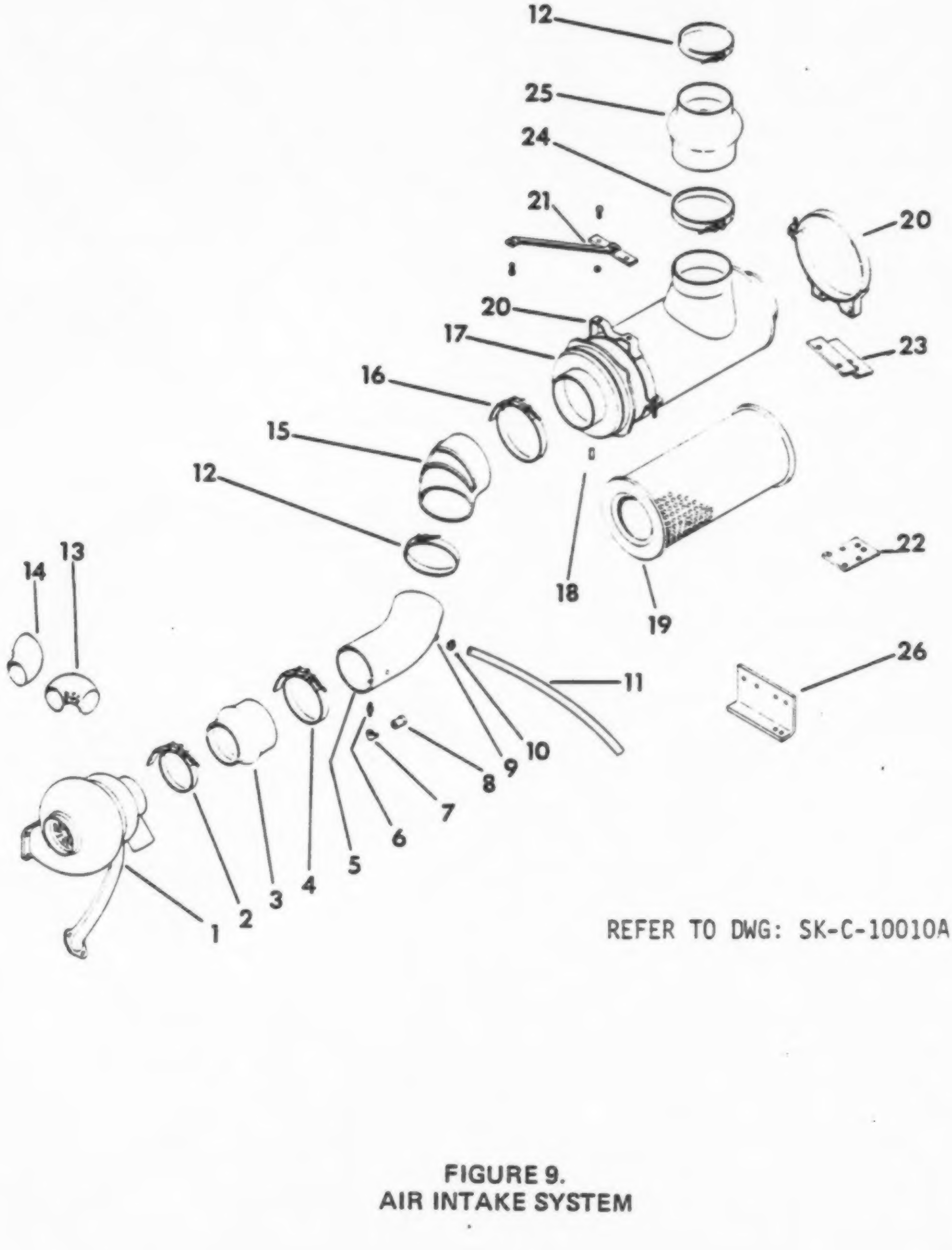
OIL FILTERS, ETC.

Originally, the exhaust manifolds emptied at the front of the engine into tubes that joined in a wye and led away to the muffler. After turbocharging, the exhaust manifolds empty toward the rear of the engine into tubes that sweep upward into a wye before entering the turbocharger. The left bank tube displaces the primary and secondary fuel oil filters bracketed above and behind the engine to its left.

Since there is no real need for the by-pass lubrication oil filter, it is removed. The space it occupied on the right side of the engine compartment where it was bracketed to the engine cradle hanger is now used for the fuel filters. Their new bracket, SK-B-10014, appears in its relative location in Figure 9. A new run of six hydraulic hoses connecting the fuel filters must be cut to length and installed.

The remote control engine-start switch box was originally mounted upon an angle clip in the upper right corner of the engine compartment. It is displaced by the new air cleaner location and dropped straight down to hang from the same angle clip by means of a new bracket, SK-B-10013, which also shows in its relative location in Figure 9.

The new air cleaner also displaces the small manifold which carries several oil pressure sending units, etc. Affected in the same way is the pressure switch that prevents the air conditioner compressor's drive from engaging at engine speeds above low idle. These items are moved downward on the firewall to a location below the new air cleaner.


12
25
24
21
20
20
17
23
16
15
12
18
19
22
14
13
26
11
10
9
8
7
6
5
4
3
2
1

REFER TO DWG: SK-C-10010A

FIGURE 9.
AIR INTAKE SYSTEM

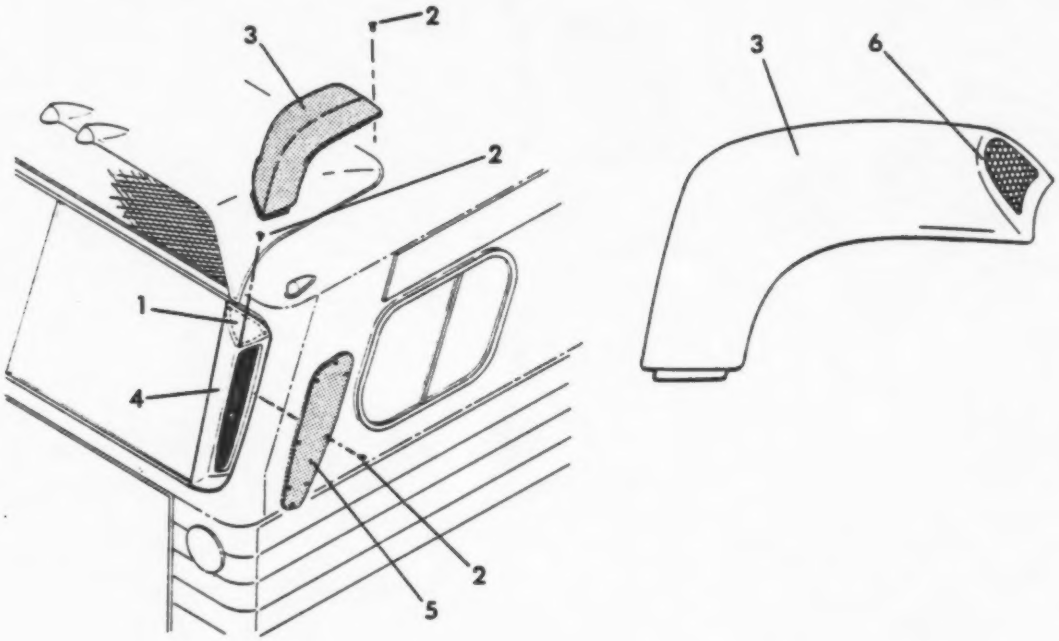
LEGEND FOR FIGURE 9.

Reference	Description	Quantity
1	Turbocharger	1
2	5½" Latch-type Band Clamp	1
3	6-to-5 Reducer	1
4	6½" Latch-type Band Clamp	1
5	45° Elbow, 6" OD	1
6	Safety Filter	1
7	1/8" NPT Street Ell	1
8	Restriction Indicator	1
9	1/8" NPT Pipe Plug	1
10	1" DIA Worm Screw Hose Clamp	1
11	1" ID Reinforced Rubber Hose	≈18"
12	6½" Band Clamp	2
13	Left Sweep Elbow Jacket	1
14	Right Sweep Elbow Jacket	1
15	7-to-6 Reducing 45° Elbow	1
16	7½" Latch-type Band Clamp	1
17	Air Cleaner	2
18	1/4" OD x 1" Copper Drain Tube	1
19	Replacement Element	*1
20	Mounting Band	2
21	Air Cleaner Strap	1
22	Switch Box Bracket	1
23	Air Cleaner Support	1
24	7½" Band Clamp	1
25	7-to-6 Reducer	1
26	Fuel Filter Bracket	1

*Included in Air Cleaner

AIR INTAKE SNORKLE

The air intake snorkle is installed in accordance with Figure 10. The template, SK-A-10020, is used to cut an opening in the top of the existing air intake cowl. The snorkle inserts into this hole and is held in place by screws. Another screw attaches the inlet end of the snorkle to the roof of the bus. The existing screen is removed from the cowl and the old inlet is closed by the plasic blank, SK-B-10016.



Legend

1 Snorkle Template SK-A-10020
2 Sheet Metal Screws
3 Holloway Snorkle SK-A-10017-A
4 Existing Intake Cowl
5 Intake Cowl Blank SK-B-10016
6 SS Wire Screen SK-A-10017-2

REFER TO DWGS:
SK-A-10016
SK-A-10017-A
SK-A-10020

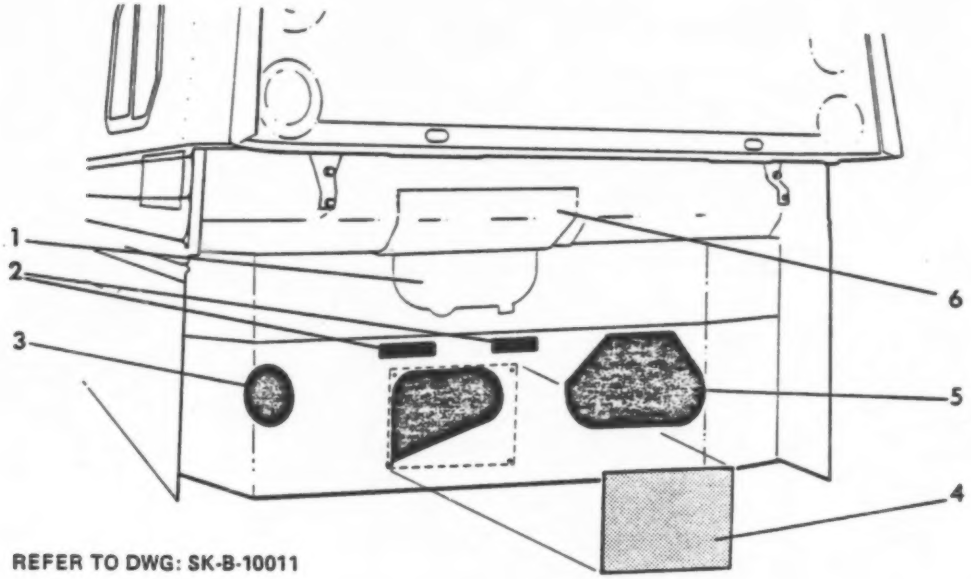
FIGURE 10.
HOLLOWAY SNORKLE INSTALLATION

EXHAUST SYSTEM

A new exhaust system is installed in order to provide the reduced back pressure required by the turbocharger (Table 3). The main changes are:

	Before	After
Tube size to muffler	4" diameter	4" diameter
Exhaust muffler	Nelson T-12023-F	Donaldson WOM12-083, modified
Tube size to stack	4" diameter	5" diameter
Exhaust aspirator	EIP Kit	Removed

The original exhaust tubing and muffler system from engine to outlet is removed. Their old passageway through the center of the firewall is covered with a steel plate as shown in Figure 11. Retaining screws pass through the firewall from front to rear and engage the cover plate on the rear side of the firewall.



REFER TO DWG: SK-B-10011

Legend

1 Access panel, seldom used and now covered by anti-noise padding
2 Plumbing passage
3 Freon compressor drive shaft passage
4 Newly fabricated exhaust pipe passage blank (SK-B-10011)
5 Drive line passage
6 Rear seat access hatch

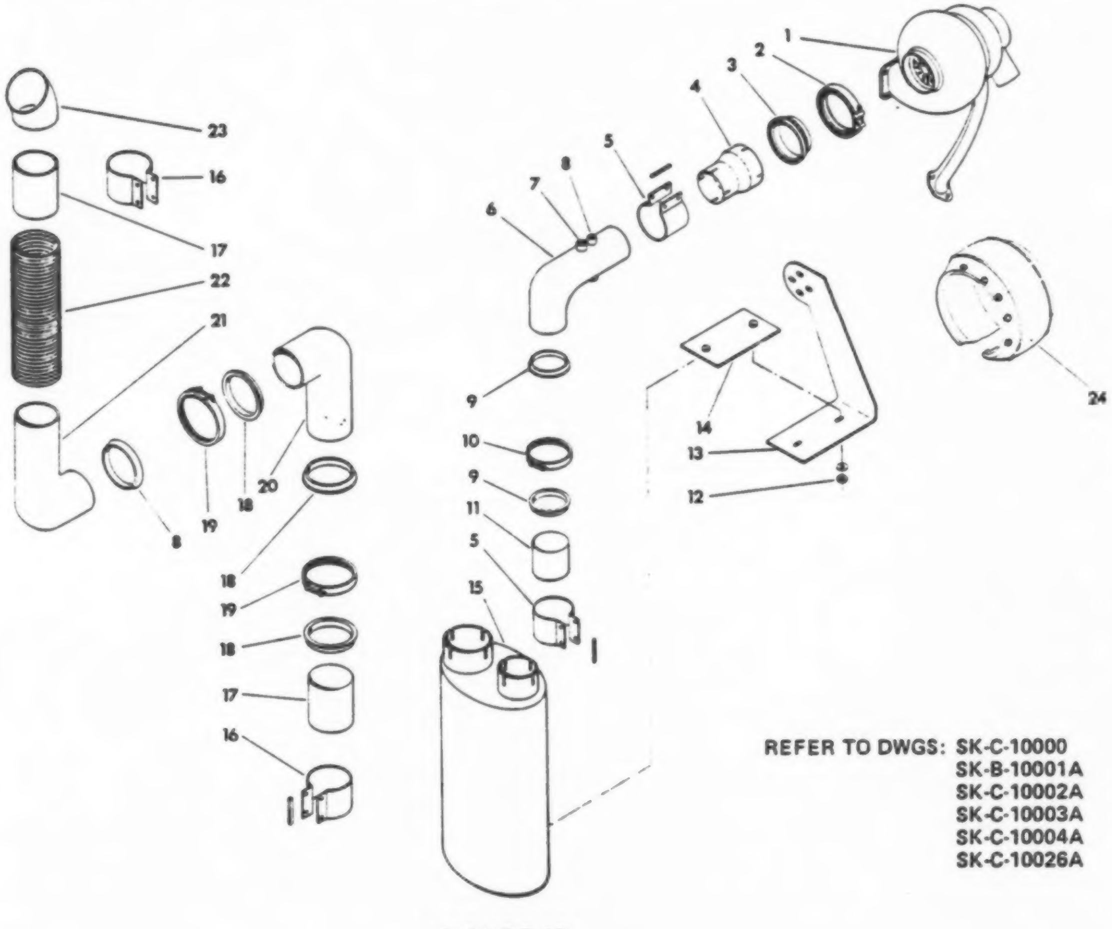
FIGURE 11.

EXHAUST PIPE PASSAGE COVER

Figure 12 depicts the new exhaust system. It features a new, smaller oval-shaped muffler. The muffler is relocated to the space between the engine and radiator formerly occupied by the "aspirator", a component of the so-called "Environmental Improvement Kit." The function of the aspirator was not replaced because it served no useful purpose to begin with.

The new muffler's body acts as a partial barrier to engine compartment noise emitting through the radiator opening. To compensate for its interference with access to the front of the engine, the muffler is bottom-mounted and jointed with v-band clamps to facilitate quick removal.

The plastic cowl located to the left of the rear window whose purpose is to conceal the stack is trimmed to fit the larger 5" diameter stack. A flexible tube section in the stack relieves stresses in the exhaust tubing produced by the relative motion between the engine and the chassis.



REFER TO DWGS: SK-C-10000
SK-B-10001A
SK-C-10002A
SK-C-10003A
SK-C-10004A
SK-C-10026A

FIGURE 12.
EXHAUST SYSTEM

LEGEND FOR FIGURE 12.

Reference	Description	Quantity
1	Turbocharger	1
2	V-band Clamp	1
3	Turbocharger Flange	1
4	5-to-4 ID-OD Reducer	1
5	4" Diameter Band Clamp	2
6	4" OD, 16 GA, MS Tube, 90° Elbow Ass'y	1
7	1/8" NPT Pipe Plug	1
8	1/4" NPT Pipe Plug	1
9	4" ID Pipe Flange	2
10	4" DIA V-band Coupling	1
11	4" OD x 4", 16 GA, MS Tube	2
12	5/16"-18NC Nut & Washer	2 ea.
13	Muffler Hanger	1
14	Muffler Mounting Plate Ass'y	1
15	Muffler	1
16	5" Diameter Band Clamp	2
17	5" OD x 6", 16 GA, MS Tube	2
18	5" ID Pipe Flange	4
19	5" DIA V-band Coupling	2
20	5" OD, 16 GA, MS Tube, 90° Elbow, 12 3/16 Long	1
21	5" OD, 16 GA, MS Tube, 90° Elbow, 13 7/8" Long	1
22	5" ID x 18", SS Flex Tube	1
23	5" OD, 16 GA, SS Tube, 45° Elbow	1
24	Turbocharger Blanket	1

AIR DRYER HISS

The air dryer is a safety device, yet it sounds dangerous. Located just downstream from the compressor, it removes condensate from the newly compressed air before the air reaches the valves, chambers, and reservoirs of the air brake system where freezing might cause blockage. Each time the compressor replenishes the air storage tanks, the same signal that unloads the compressor opens the dryer's sump valve, allowing the pent up air within to blow the collected condensate down onto the street below. This causes a loud, prolonged hissing noise. Often this will occur about a half-block after the bus pulls away from a boarding station. Since it sounds like something dramatic is happening with the airbrakes, it scares people, creating an unnecessary sense of alarm and annoyance.

Figure 13 shows a harmless way to silence the air dryer. Simply run a line from the sump to the exhaust pipe upstream of the muffler where there is a fitting provided. Any condensate, oil carryover, or other debris in the air dump is safely dissipated in the hot exhaust gas.

REF.	DESCRIPTION
1	Air Dryer
2	Adapter
3	1/4 NPT Male Elbow
4	Brass Insert
5	3/8" OD Nylon Tube
6	Union Elbow
7	3/8" OD Copper Tube
8	90° Elbow
9	1/4" NPT Male Connector

REFER TO DWG: SK-A-10008-A

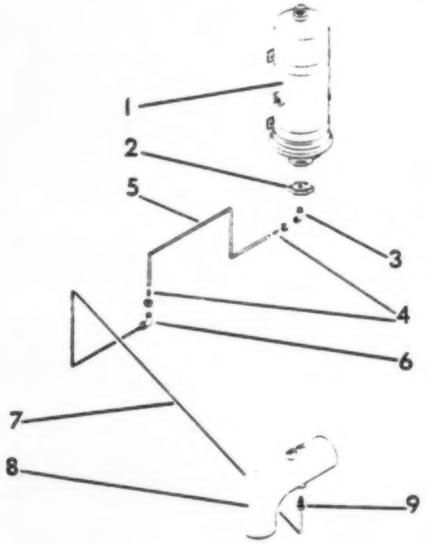


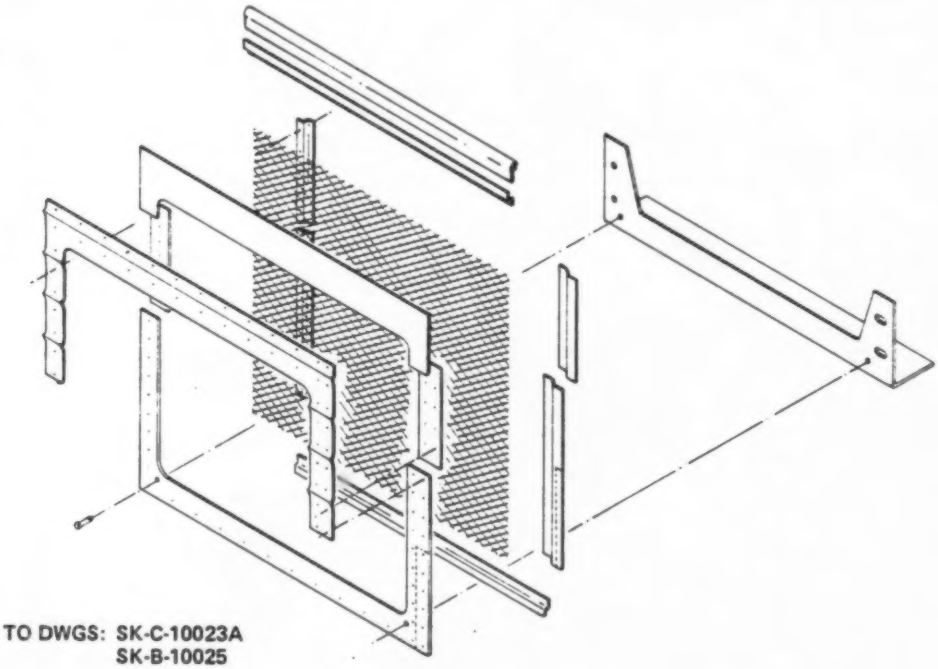
FIGURE 13.
AIR DRYER SILENCING

RADIATOR GRILLE

The turbocharger removes heat from the exhaust gas. Most of this missing heat is transferred to the engine's cooling system. The cooling load is increased 11%. To offset this extra load, the radiator grille is rebuilt, giving a 45% larger net area. This results in a 12% increase in air flow at the same fan speed which, in turn, results in a 7% greater heat rejection from the same radiator without a rise in coolant temperature. The end result is a slight reduction in the cooling system's capacity. However, the cooling system has surplus capacity in our buses to prevent overheating of the engine in any environmental condition, provided that it is kept in reasonably good working order. Therefore, rather than take the next step, which would be to replace the existing 4-tube row radiator core with a 5-row core, it is better to pay attention to routine service items such as:

1. Steamclean air side of radiator and keep clean.
2. Do not discard any part of the fan shroud.
3. Keep fan centered in shroud.
4. Keep fan drive thermostat valve working.

Figure 14 shows how the existing grille is salvaged and rebuilt.



REFER TO DWGS: SK-C-10023A
SK-B-10025

FIGURE 14.
REWORKED RADIATOR GRILLE

Figure 15 compares the old grille with the new grille.

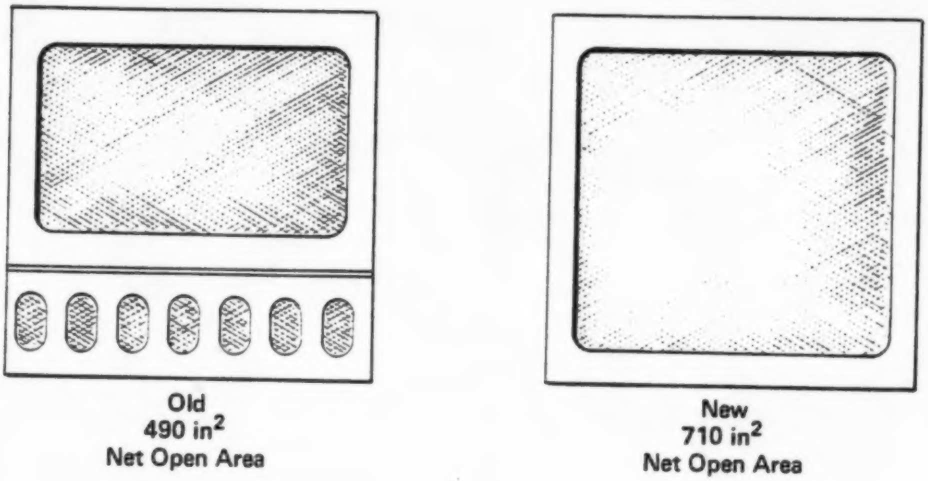


FIGURE 15.
OLD AND NEW GRILLES

A grille having a still greater open area does not result in a further increase in air flow. This is because the "bottleneck" lies elsewhere. The net open area of the radiator core is 720 in^2 and the area of the shroud opening is 710 in^2. The next step in improving air flow would be either to redesign the fan-shroud interaction or increase the size of the radiator, shroud, and fan.

ESTIMATED COST

It is estimated that the cost of applying the treatment is about $6,000 per bus. Most of this amount is associated with turbocharging the engine. In making this estimate, itemized in Table 4, it is assumed that:

Only one or a few buses will be treated at a time.
Workmen are unrehearsed, but supervised and well motivated.
No special tooling is built up.
Common tools, parts, materials, and outside fabricators are available.
Prices are at the 1979 level.
Shop labor and overhead rate is $20 per man-hour.
Purchases are below levels deserving quantity discounts.

In the interest of economy, the engine is turbocharged at the same time it is undergoing an overhaul. The net cost of rebuilding the engine into an 8V-71T over the cost of restoring it to an 8V-71N is used.

TABLE 4.

COST ESTIMATE

SHOP LABOR	Build Up	Install	Total
Overhaul to 8V-71T	42	8	50
Overhaul to 8V-71N	32	8	40
Net to turbocharge	10	0	10
Anti-noise padding	7½	5½	13
Air intake system	¼	2¼	2½
Oil filters, etc.	1	2½	3½
Air intake snorkle	½	1	1½
Exhaust system	2½	6½	9
Air dryer line		2	2
Radiator grille	3½	½	4
Total man-hours	25¼	20¼	45½

COSTS	Purchased Parts	Build Up Labor	Outside Fabricate	Install Labor	Total
Overhaul to 8V-71T	$7,200	$840	$ 0	$160	$8,400
Overhaul to 8V-71N	4,800	640	0	160	5,800
Net to turbocharge	2,400	200	0	0	2,600
Anti-noise padding	611	150	0	110	871
Air intake system	514	5	50	45	614
Oil filters, etc.	40	20	0	50	110
Air intake snorkle	12	10	600	20	642
Exhaust system	578	50	210	130	968
Air dryer line	20	0	0	40	60
Radiator grille	20	70	0	10	100
Total cost	$4,195	$505	$860	$405	$5,965

ACOUSTICS

Sound is vibration in air...pressure waves. Noise is unwanted sound.

The human ear is an extremely sensitive and delicate organ. A young person can detect a sound whose air pressure is only one two-ten thousandths of a millionth of an atmosphere. The ear can momentarily function even when exposed to sound pressure 10 million times this threshold.

Sound is measured with a sound level meter and is usually expressed in terms of A-weighted decibels. The sound level meter consists of a microphone, an amplifying electronic network, and a readout. Too many digits would be involved if sound were expressed in plain pressure units, so decibels are used to make the numbers simpler. A decibel is 20 times the logarithm (power of ten) of the ratio of the measured sound pressure to a reference sound pressure. The reference is the threshold of human hearing. A sound having a thousand times the pressure of the human threshold would have a decibel rating of 60 dB. A-weighting means that the signal is sent through a filter that downgrades low frequency sound corresponding to the response of the human ear.

One does not use simple arithmetic with decibels. For example, 80 dBA plus 80 dBA does not equal 160 dBA. As a matter of fact, every time sound pressure doubles, the sound level increases by 3 dBA. 80 + 80 = 83 dBA.

If one sound is 10 dBA louder than another, the lesser is masked out. That is, the sound level of the two together is not detectably greater than the greater sound. When a particular noise source is 10 dBA less than the overall noise, then it is unimportant.

Distance has a predictable effect on sound level. Each time one doubles the distance to a sound source radiating from a point in an echo-free space, the sound level drops by 6 dBA.

Juries won't agree that there is a difference in level when sounds less than 3 dBA are compared. A sound 10 dBA less than another seems half as loud.

When trying to stop noise by putting a box around the source, one should keep these things in mind:

1. A lot of noise comes through a small hole. An air leak is usually a noise leak too.
2. Kill "live" panels (they ping when you strike them) by stiffening them or by gluing something heavy to them.
3. The walls of the box have to be relatively heavy. Usually a pound or two per square foot is enough.
4. Some kind of sound absorptive lining inside of the box is good because it reduces echoes inside. If it becomes less noisy inside the box, it will become less noisy outside the box too.
5. If you can't put a complete box around the source, at least try to put barriers to cut off line-of-sight noise. That is better than leaving open holes.

A bus is a chorus of individual noises. These can be grouped as engine compartment noise, fan noise, exhaust outlet noise, muffler and exhaust pipe shell noise, and tire and body noise.

Engine noise is both sensitive to speed and power. It has a harsh, unpleasant quality. It is the most difficult noise source to treat and is therefore usually the dominant source after the overall bus has been treated. It can be helped by the engine manufacturer through smoothing of the onset of combustion, by stiffening the block, and by curing "hot spots." But, this takes a long time and is expensive. Other treatments are turbocharging and encapsulation.

The fan makes a whirring sound, coming from where the blade tips chop the air. It is steeply sensitive to fan speed, so a modulating speed drive is better for noise control than an on-off drive. At least sometimes you will hear the fan if it has an on-off drive, but you might never be bothered by fan noise with a modulating speed drive. Nothing much can be done to cure fan noise except to slow the fan down. This is more easily done at the factory through the use of larger radiators than in the field.

Exhaust outlet noise is more mellow and musical. Most uninitiated believe they are hearing exhaust noise and blame the muffler when a loud bus goes by. It might well be a break in the exhaust piping upstream of the muffler, or more often just plain engine noise they are hearing. Exhaust noise is relatively easy to treat. All one needs is a proper muffler. With turbocharged engines, there is a need for low back pressure. This leads to the problem of finding room for the adequate muffler. To have low back pressure *and* good silencing, a muffler can't be kept small.

Muffler and exhaust pipe shell noises might be revealed as treatment of the louder engine, exhaust, and fan noises progresses. Common practice is to double the skin of the muffler body when used with naturally aspirated engines. The need is less with turbocharged engines. Pipe shell noise does not ordinarily require treatment, but there might be significant noise radiating from flexible tube sections.

Tire noise is unimportant at speeds below 40 mph for the ordinary bus. Even after treatment, tire noise is masked out at speeds below 30 mph. Body noise can be a nuisance if there are loose doors and windows.

Noise radiates in all directions from a bus of the type we treat here, but not evenly. Less noise radiates forward because the bus body is a barrier to engine noise in the rear. The bus is noisier on the left side than on the right, not because the exhaust stack is on that side, but because the radiator opening is there... an open door to noise from the engine compartment. Fortunately, the boarding passengers are exposed to right side noise which is quieter and easier to treat than left side noise.

We believe the operator of a city transit bus should judge a treatment by its effect on the ordinary noise a bus makes most of the time; not on the maximum noise it makes only once in awhile. A treatment that reduces the one does not necessarily reduce the other. Consequently, we believe it is better to evaluate the bus with its fan drive in the "as-is" condition and not artificially locked up. We use the following criteria:

Exterior Noise.
Average of right side and left side peak sound level during a 50-foot full acceleration pass-by through first upshift.

Interior Noise.
Average of rear seat and driver's seat peak sound level during full acceleration through first upshift.

By these criteria, the results of treating a bus in accordance with this Retrofit Instruction are:

	As-Is Average Exterior Rating*	As-Is Average Interior Rating*
Baseline (Typical Tri-Met)	79½ dBA	79½ dBA
After Treatment	75½ dBA	76½ dBA
Reduction	4 dBA	3 dBA

*Rounded to the nearest ½ dBA

An acoustically effective bellypan would make possible a further reduction to the average exterior rating of at least 3dBA, but this has not been reduced for practical hardware.

A more detailed breakdown by side and source is given in Table 4. This enables comparison with other standards such as the U.S. EPA proposed rule for regulating manufacturers of buses. The EPA rule is "worst-case" oriented. It considers only the "fan-on" condition and the louder side or end. The proposed levels are:

	Exterior	Interior
First year	83 dBA	86 dBA
Fifth year	80 dBA	83 dBA
Seventh year	77 dBA	80 dBA

TABLE 5.

NOISE SOURCE DIAGNOSIS BEFORE AND AFTER TREATMENT
Measured by EPA 50-foot Acceleration Pass-by Test

(Rounded to Nearest ½ dBA)

BASELINE

EXTERIOR		LEFT	RIGHT
SOURCE	ENGINE	79	77½
	SHELL	73	70
	EXHAUST	66	65
	TIRES	58	58
	FAN ON	77	76½
	FAN AS-IS	71	70½
OVERALL	FAN ON	*82	81
	FAN AS-IS	80	79
	FAN OFF	80	78½
INTERIOR		REAR	FRONT
	FAN ON	*83½	77½
	FAN AS-IS	83	76

TREATED

EXTERIOR		LEFT	RIGHT
SOURCE	ENGINE	74½	73½
	SHELL	NIL	NIL
	EXHAUST	65	64
	TIRES	58	58
	FAN ON	77½	73
	FAN AS-IS	71	65
OVERALL	FAN ON	*79½	76½
	FAN AS-IS	76½	74½
	FAN OFF	75	74
INTERIOR		REAR	FRONT
	FAN ON	*80½	74½
	FAN AS-IS	80	73

*Comparable to EPA Rating

EFFECTS ON PERFORMANCE

Table 5 quantifies the side-effects of the noise control treatment on various aspects of bus performance. It complements the data presented in Table 3. In general, emissions and aspiration are improved, delivered power and fuel economy are unchanged or slightly improved, cooling system capacity is affordably decreased. Predicted aggregate maintenance costs are not measurably changed.

TABLE 6.
PERFORMANCE BENCHMARKS BEFORE AND AFTER TREATMENT
(#1 Diesel Fuel)

	UNITS	BASELINE	TREATED
POWER OUTPUT			
Terminal Speed on 4% Grade	mph	45½	46
Acceleration on Flat [1]200-foot Time	sec	8.7	8.8
[2]Engine Dynamometer Full throttle, 2,000 rpm	BHP	218	220
FUEL MILEAGE			
Average Mission	mpg	[3]4.22	[4]4.40
COOLING SYSTEM			
Full Speed on 4% Grade	[5]°F ATB	134°	127½°
Fan Delivery, 1,500 rpm	CFM	10,500	12,000
ASPIRATION (Full Power, 2,000 rpm)			
Exhaust Back Pressure	"Hg	5.6	2.1
Exhaust Temperature	°F	810°	560°
Intake Restriction	"H_2O	7	11

[1] Full throttle from a standing start.

[2] Data supplied by engine manufacturer.

[3] 2-year fleet average.

[4] 5½ months in-service average.

[5] The ambient air temperature at which the coolant would theoretically warm up to the boiling point of water, 212°F.

ABBREVIATIONS

AGE	Aluminized Glass Edging Tape
AL, ALUM	Aluminum
ATB	Air-to-Boil Temperature
μbar	One-millionth of an atmosphere of pressure
B.C.	Bolt Circle
BHP	Brake Horsepower
BMEP	Brake Mean Effective Pressure
BSFC	Brake Specific Fuel Consumption
BTU	British Thermal Unit
CFM	Cubic Feet per Minute
CO	Carbon Monoxide
dBA	A-weighted decibel referenced to .0002 μbar
DIA, dia	Diameter
DWG	Drawing
EIP	Environmental Improvement Package
°F	Degree Fahrenheit
Flex	Flexible
ft^2	Square Foot
GA	Gage
GPM	Gallons per Minute
HC	Hydrocarbons
"Hg	Inches of Mercury
"H_2O	Inches of Water
hr	Hour
ID	Inside Diameter
in^2	Square Inches
INST.	Installation
L.B.	Left Bank
lbs	Pounds
min	Minute
mm	Millimeter
mpg	Miles per Gallon
mph	Miles per Hour
M.S.	Mild Steel
MTG	Mounting
NC	National Coarse Thread
NO_2	Nitrous Oxide
NPT	National Pipe Thread
OD	Outside Diameter
oz	Ounce
PPM	Parts per Million
psi	Pounds per Square Inch
R, RAD	Radius
REF	Reference
R.B.	Right Bank
rpm	Revolutions per Minute
sec	Second
S.S.	Stainless Steel
TYP	Typical

APPENDIX A.

PURCHASE LIST

Notes:

1. Parts for turbocharge rebuild to be negotiated with local Detroit Diesel dealer.
2. Common fasteners not called out.

Quantity	Brand or Manufacturer	Size or Part Number	Description	Where Used
1	Aeroquip	55083-650-2	6½" Band Clamp	SK-C-10010A
1	Aeroquip	MB9460-S-100-N-750	7½" Latch Band Clamp	SK-C-10010A
1	Aeroquip	55083-750-2	7½" Band Clamp	SK-C-10010A
1	Aeroquip	MB9360-S-075-N-550	5½" Latch Band Clamp	SK-C-10010A
1	Aeroquip	MB9460-S-100-N-650	6½" Latch Band Clamp	SK-C-10010A
2	Aeroquip	MLJ 8750-500S	5" Servicemaster	SK-C-10002A
1	Aeroquip	MLJ 8750-400S	4" Servicemaster	SK-C-10002A
1	Bostitch	P50-5B	Pnuematic Stapler	IC Pads
1	Bostitch	SB-5019-5/8"	S.S. Staples	IC Pads
40" x 88"	Carborundum	Grade FW35	Flexweave 1000 Cloth	SK-A-10003A
1	Detroit Diesel	5101814	Turbocharger Flange	SK-C-10005A
1	Detroit Diesel	5132650	V-Band Clamp	SK-C-10005A
2	Donaldson	17061	5" Sealclamp	SK-C-10002A SK-C-10004A
2	Donaldson	KYX00-4482	4" Sealclamp	SK-C-10005A
1	Donaldson	5080B79	WOM12-83, Modified	SK-C-10004A
1	Donaldson	21067	4-5 ID-OD Reducer	SK-C-10005A
1	Donaldson	23013	6" OD 45° Elbow	SK-A-10009A
1	Donaldson	P10-0089	Safety Filter	SK-C-10010A
1	Donaldson	RBX00-2278	Restriction Indicate	SK-C-10010A
1	Donaldson	ECG11-2000	Air Cleaner	SK-C-10010A
2	Donaldson	P00-4079	Mounting Band	SK-C-10010A
18" Long	Federal	R200S	5" ID S.S. Flex Tube	SK-C-10002A
1	HITCO	298S27644	Turbo-Charger Blkt.	SK-C-10026A
1	HITCO	298S27664	L.B. Elbow Blanket	SK-C-10010A
1	HITCO	298S27663	R.B. Elbow Blanket	SK-C-10010A
1	Holloway	SK-A-10017A	Snorkle	Sk-A-10024A
1	Huntington	60R50	6-5 Rubber Reducer	SK-C-10010A
1	Huntington	70R60	7-6 Rubber Reducer	SK-C-10010A
1	Huntington	45HL70R60	7-6 Reducer 45°Elbow	SK-C-10010A
1 25' Roll	Insul-Coustic	Type 6, 10 oz/ft^2	48" Wide Insul-Quilt	IC Pads
1 Roll	Insul-Coustic	3" Wide x 400 Yards	AGE Tape	IC Pads
6	Insul-Coustic	IC 998	Adhesive Cartridge	IC Pads

APPENDIX A.

PURCHASE LIST CONTINUED

Quantity	Brand or Manufacturer	Size or Part Number	Description	Where Used
15" x 38"	Local Supply	3/16" Thick	M.S. Plate	SK-C-10000 SK-B-10001A
20" x 28"	Local Supply	1/8" Thick	M.S. Plate	SK-A-10011 SK-B-10012 SK-A-10013 SK-B-10014
3" x 15"	Local Supply	1/4" Thick	M.S. Plate	SK-C-10015A
14" x 36"	Local Supply	5/32" Thick	M.S. Plate	SK-C-10023A
26" x 32"	Local Supply	1/8" Thick	Alum Sheet	SK-C-10021A
6'	Local Supply	1/8" x 3" x 3"	Alum Angle	SK-C-10019A
31" x 33"	Local Supply	1" x 2" Diamond	M.S. Expanded Mesh	SK-C-10023A
1" Long	Local Supply	1" OD x .065" Wall	M.S. Tube	SK-A-10009A
1" Long	Local Supply	1/4" OD	Copper Tube	SK-C-10010A
6'	Local Supply	SAE J844B, Type 1	3/8" OD Copper Tube	SK-A-10008A
10'	Local Supply	SAE J844B, Type 3	3/8" OD Nylon	SK-A-10008A
2" Long	Local Supply	2" Hexagonal	Brass Bar	SK-A-10007
6" x 24"	Local Supply	1/8" Thick	Polypropylene Sheet Haircell Black	SK-B-10016
2'	Local Supply	1" OD	Rein Rubber Hose	SK-C-10010A
1	Local Supply	5" OD, 16 GA	S.S. 45° Elbow	SK-C-10002A
4	Local Supply	1/8" NPT	Pipe Coupling	SK-C-10005A SK-C-10009A
1	Local Supply	1/4" NPT	Pipe Coupling	SK-C-10005A
3	Local Supply	1/8" NPT	Pipe Plug	SK-C-10005A SK-C-10009A SK-C-10010A
1	Local Supply	1/4" NPT	Pipe Plug	SK-C-10005A
1	Local Supply	1" DIA	Worm Hose Clamp	SK-C-10010A
1	Parker	2202P-2-2	1/8" NPT Street Ell	SK-C-10010A
1	Parker	269CA-6-4	1/4" NPT Male Elbow	SK-A-10008A
1	Parker	165CA-6	Union Elbow	SK-A-10008A
2	Parker	63PT-6-62	Brass Insert	SK-A-10008A
1	Parker	68CA-44	1/4" NPT Male Conn.	SK-A-10008A
12" x 12"	Western Wire	16 GA, 4 Mesh	T304 S.S. Screen	SK-A-10017A

APPENDIX A.

SPECIALTY SUPPLIERS

HITCO Insulation Products
2302 Marietta Blvd, N.W.
Atlanta, Georgia 30318
(404) 355 1205

Insul-Coustic
Jernee Mill Road
Sayreville, New Jersey 08872
(201) 257 6674

Huntington Rubber Co.
6800 S.W. Macadam Blvd.
Portland, Oregon 97219
(503) 246 5411

Holloway Product Development
14023 N.W. Science Park Drive
Portland, Oregon 97229
(503) 643 7338

Carborundum Co.
Insulation Division
P.O. Box 808
Niagra Falls, N.Y. 14302
(716) 278 6221

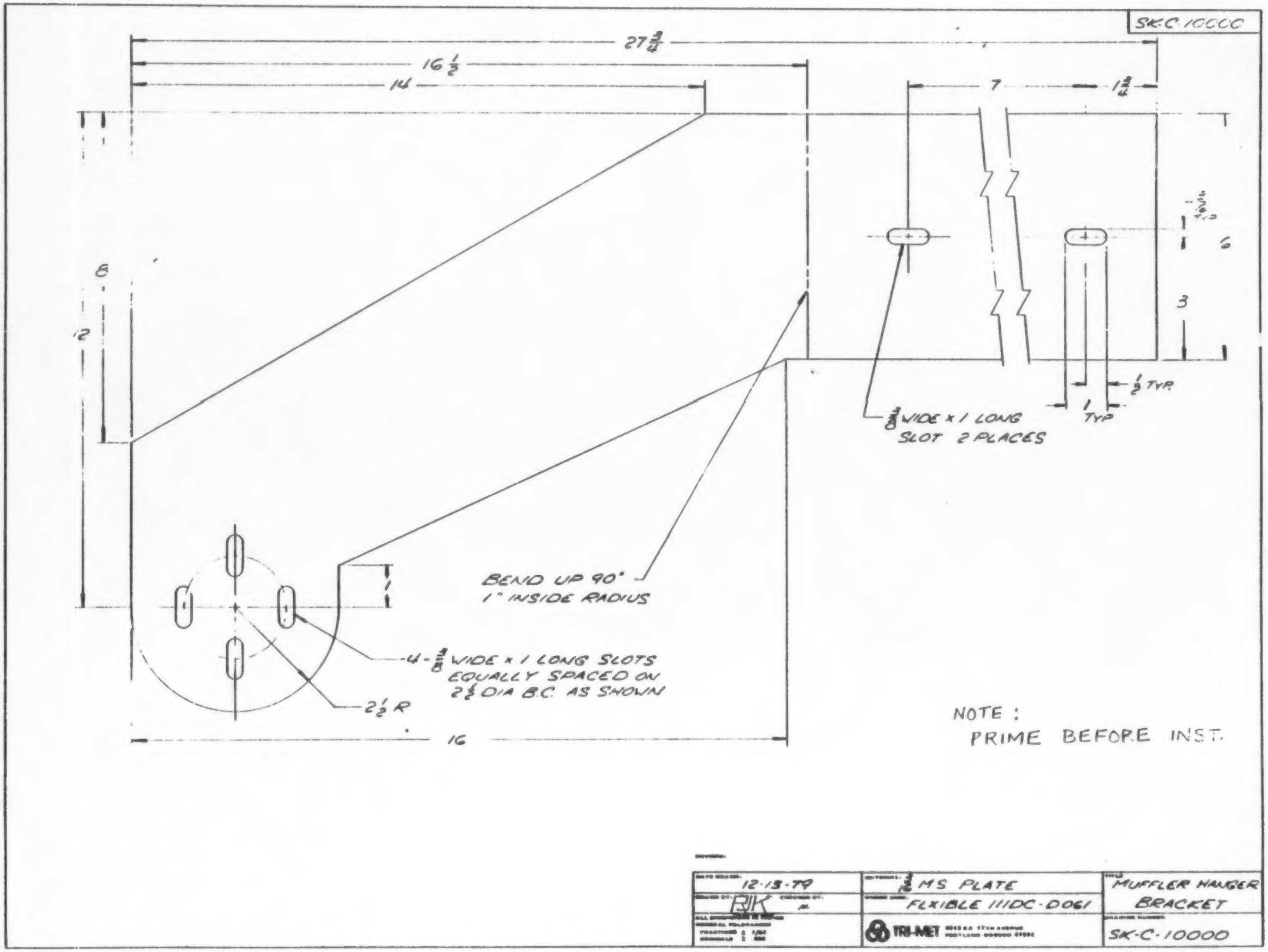
Donaldson Co., Inc.
1400 W. 94th St.
Minneapolis, Minnesota 55440

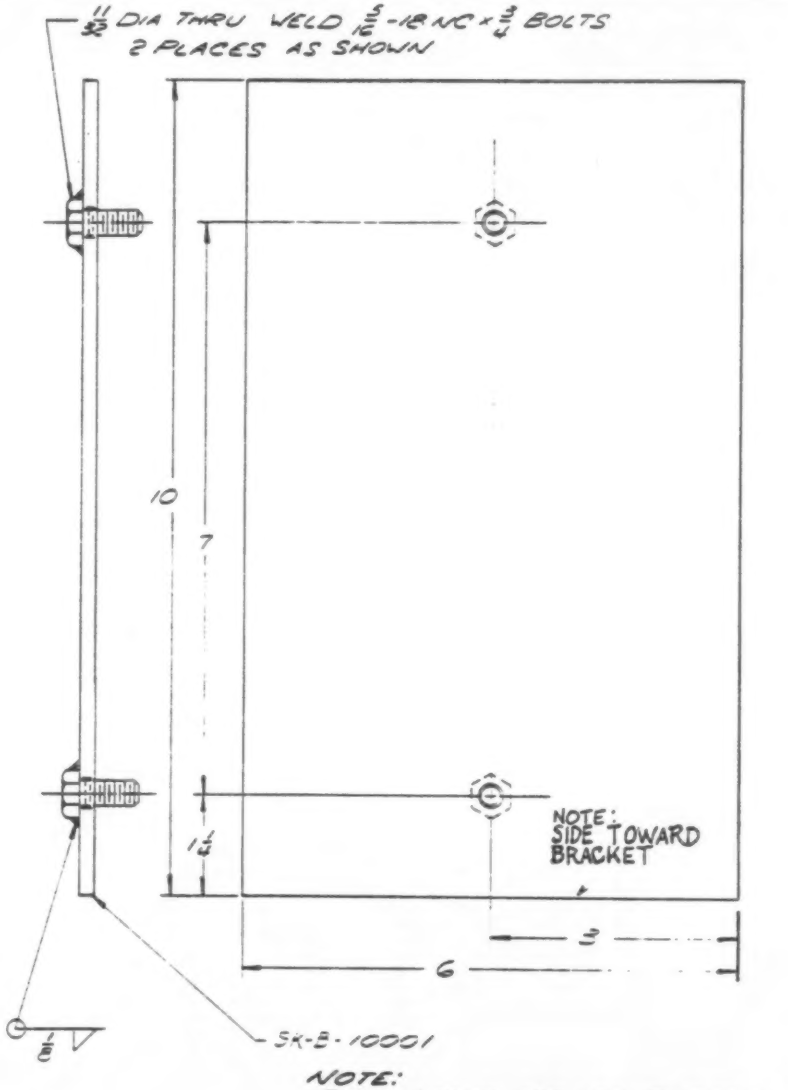
Western Wire Works
4025 N.W. Express
Portland, Oregon 97210
(503) 222 1644

APPENDIX B.

TRI-MET DRAWINGS

Number	Title
SK-C-10000	MUFFLER HANGER BRACKET
SK-B-10001A	MUFFLER MOUNTING PLATE ASS'Y
SK-C-10002A	UPPER EXHAUST ASS'Y
SK-A-10003A	MUFFLER JACKET ASS'Y
SK-C-10004A	LOWER EXHAUST ASS'Y
SK-C-10005A	EXHAUST INLET ASS'Y
SK-A-10007	DRYER ADAPTER
SK-A-10008A	DRYER AIR LINE INST
SK-C-10009A	INTAKE ELBOW ASS'Y
SK-C-10010A	INTAKE SYSTEM INST
SK-B-10011	FIREWALL BLANK
SK-B-10012	AIR CLEANER SUPPORT
SK-A-10013	SWITCH BOX BRACKET
SK-B-10014	FUEL FILTER BRACKET
SK-C-10015A	AIR CLEANER STRAP ASS'Y
SK-B-10016	INTAKE COWL BLANK
SK-A-10017A	HOLLOWAY SNORKLE ASS'Y-FLX
SK-C-10018A	REAR DOOR PADDING
SK-C-10019A	DOOR STOP
SK-A-10020	SNORKLE TEMPLATE
SK-C-10021A	FIREWALL PADDING
SK-C-10022A	RADIATOR PADDING
SK-C-10023A	REBUILT GRILLE
SK-A-10024A	SNORKLE INST
SK-B-10025	GRILLE SUPPORT
SK-C-10026A	EXHAUST SYSTEM INST

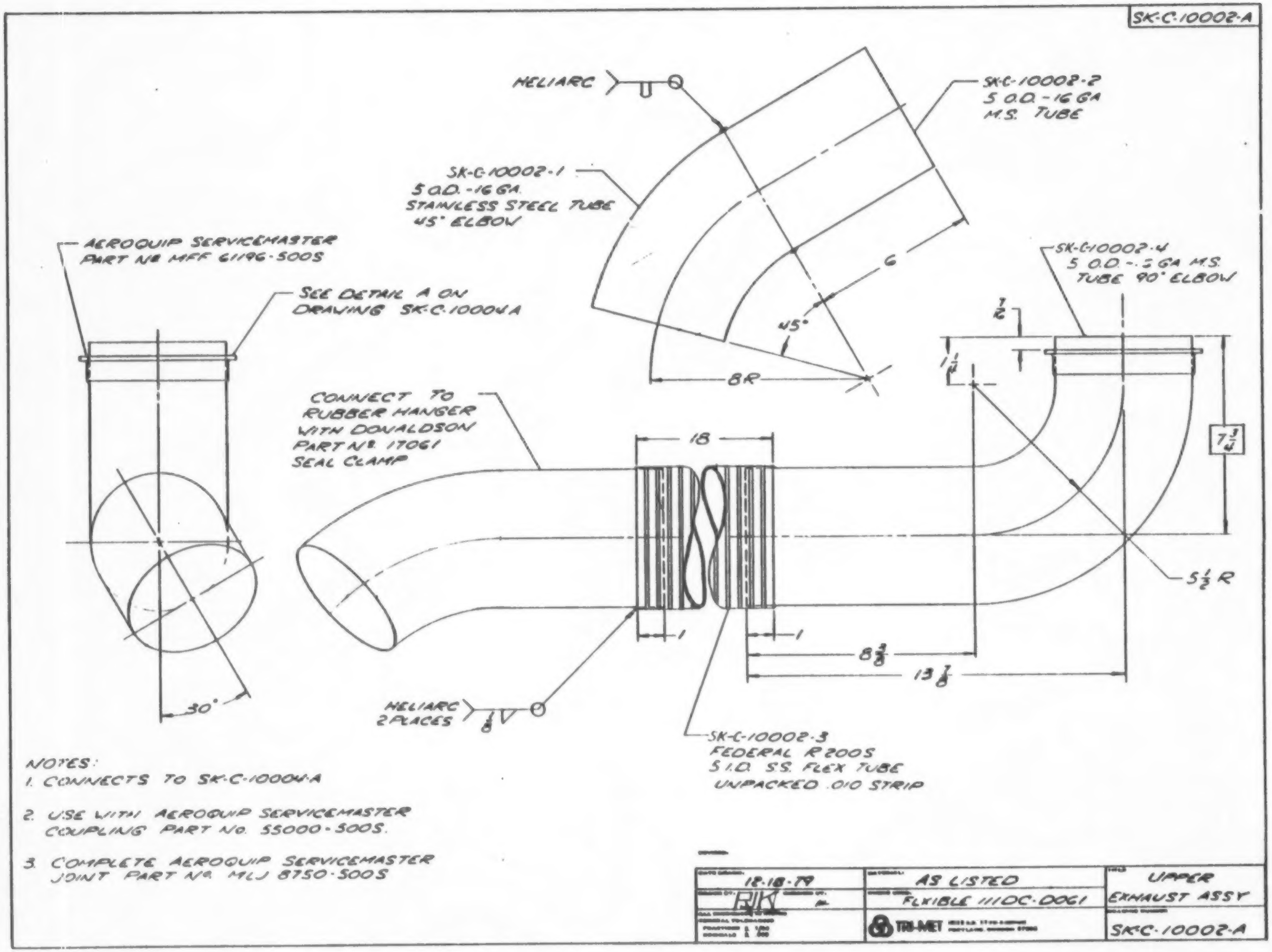

SK-C-10000
27 3/4
16 1/2
14
7
1 3/4
8
12
6
3/8 TYP
3
1/2 TYP
1 TYP
3/8 WIDE x 1 LONG SLOT 2 PLACES
BEND UP 90° 1" INSIDE RADIUS
1
4-3/8 WIDE x 1 LONG SLOTS EQUALLY SPACED ON 2 5/8 DIA B.C. AS SHOWN
2 1/2 R
16
NOTE :
PRIME BEFORE INST.
12-13-79
RJK
3/16 MS PLATE
FLXIBLE 111DC-D061
TRI-MET
MUFFLER HANGER BRACKET
SK-C-10000


$\frac{11}{32}$ DIA THRU WELD $\frac{5}{16}$-18 NC × $\frac{3}{4}$ BOLTS
2 PLACES AS SHOWN
10
7
$1\frac{1}{4}$
NOTE:
SIDE TOWARD
BRACKET
3
6
$\frac{1}{8}$
SK-B-10001

NOTE:
FIELD WELD ACROSS BOTTOM
OF MUFFLER AFTER ALIGNMENT
WITH EXHAUST SYSTEM

REVISED:

DATE DRAWN: DEC 9, 1979	MATERIAL 3/16 M.S. PLATE	TITLE MUFFLER MTG PLATE ASS'Y
DRAWN BY: RJK CHECKED BY:	WHERE USED FLXIBLE 111DC-D061	
ALL DIMENSIONS IN INCHES GENERAL TOLERANCES FRACTIONS ± 1/64 DECIMALS ± .005	TRI-MET 4012 S.E. 17TH AVENUE PORTLAND, OREGON 97202	DRAWING NUMBER SK-B-10001 A

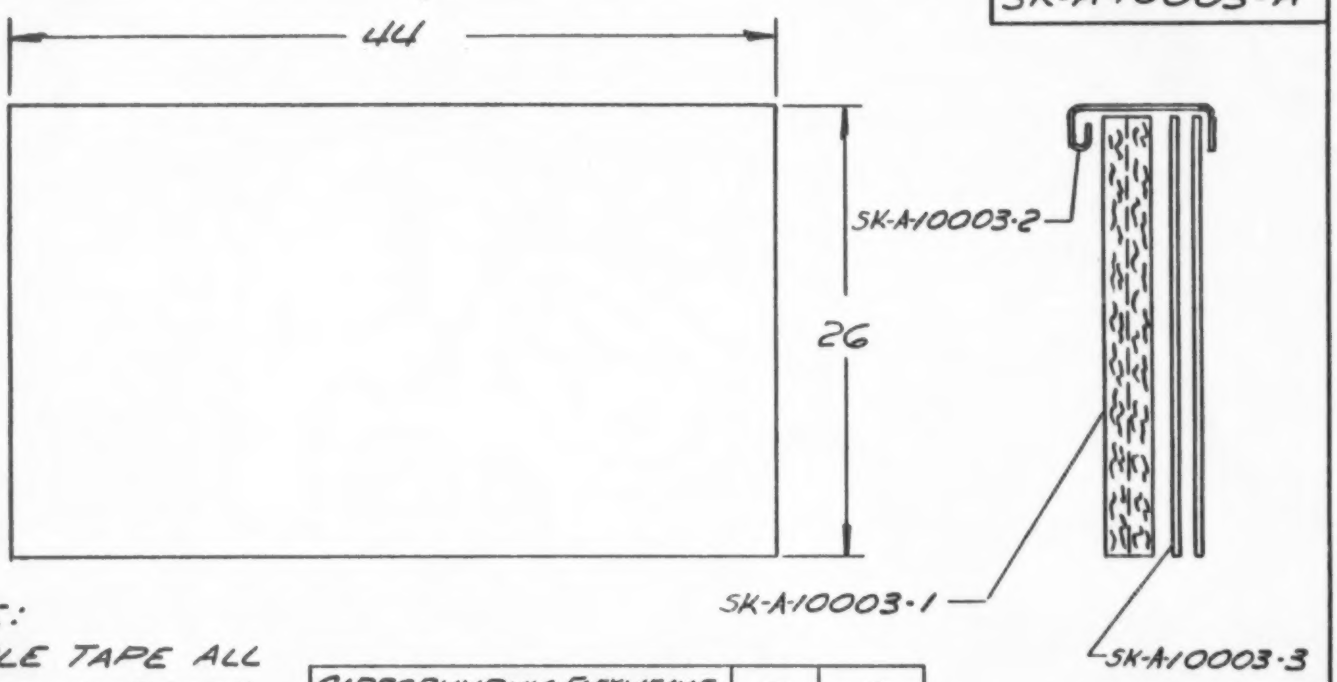

SK-C-10002-A
HELIARC
SK-C-10008-2
5 O.D. -16 GA
M.S. TUBE
SK-C-10002-1
5 O.D. -16 GA.
STAINLESS STEEL TUBE
45° ELBOW
6
45°
8R
AEROQUIP SERVICEMASTER
PART Nº MFF 6196-500S
SEE DETAIL A ON
DRAWING SK-C-10004-A
SK-C-10002-4
5 O.D. -.5 GA M.S.
TUBE 90° ELBOW
7/16
1 1/4
7 3/4
CONNECT TO
RUBBER HANGER
WITH DONALDSON
PART Nº 17061
SEAL CLAMP
18
5 1/2 R
1
1
8 3/8
13 7/8
30°
HELIARC
2 PLACES
1/8
SK-C-10002-3
FEDERAL R200S
5 I.D. S.S. FLEX TUBE
UNPACKED .010 STRIP

NOTES:

1. CONNECTS TO SK-C-10004-A
2. USE WITH AEROQUIP SERVICEMASTER COUPLING PART No. 55000-500S.
3. COMPLETE AEROQUIP SERVICEMASTER JOINT PART Nº MLJ 8750-500S

12-18-79
RJK
AS LISTED
FLXIBLE 1110C-0061
TRI-MET
UPPER
EXHAUST ASSY
SK-C-10002-A

SK-A-10003-A



NOTE:
STAPLE TAPE ALL
AROUND EDGE
STAPLE SPACING
1 - 1 1/2

REVISED:

	QTY	DASH
CARBORUNDUM FLEXWEAVE 1000 CLOTH GRADE FW35	2	3
INSUL-COUSTIC AGE TAPE 3" WIDE	1	2
INSUL-QUILT TYPE 6 10 OZ/SQ FT.	1	1

MATERIAL:

DATE DRAWN: 12-16-79

DRAWN BY: RJK
CHECKED BY: MK

ALL DIMENSIONS IN INCHES
GENERAL TOLERANCES
FRACTIONS ± 1/64
DECIMALS ± .005

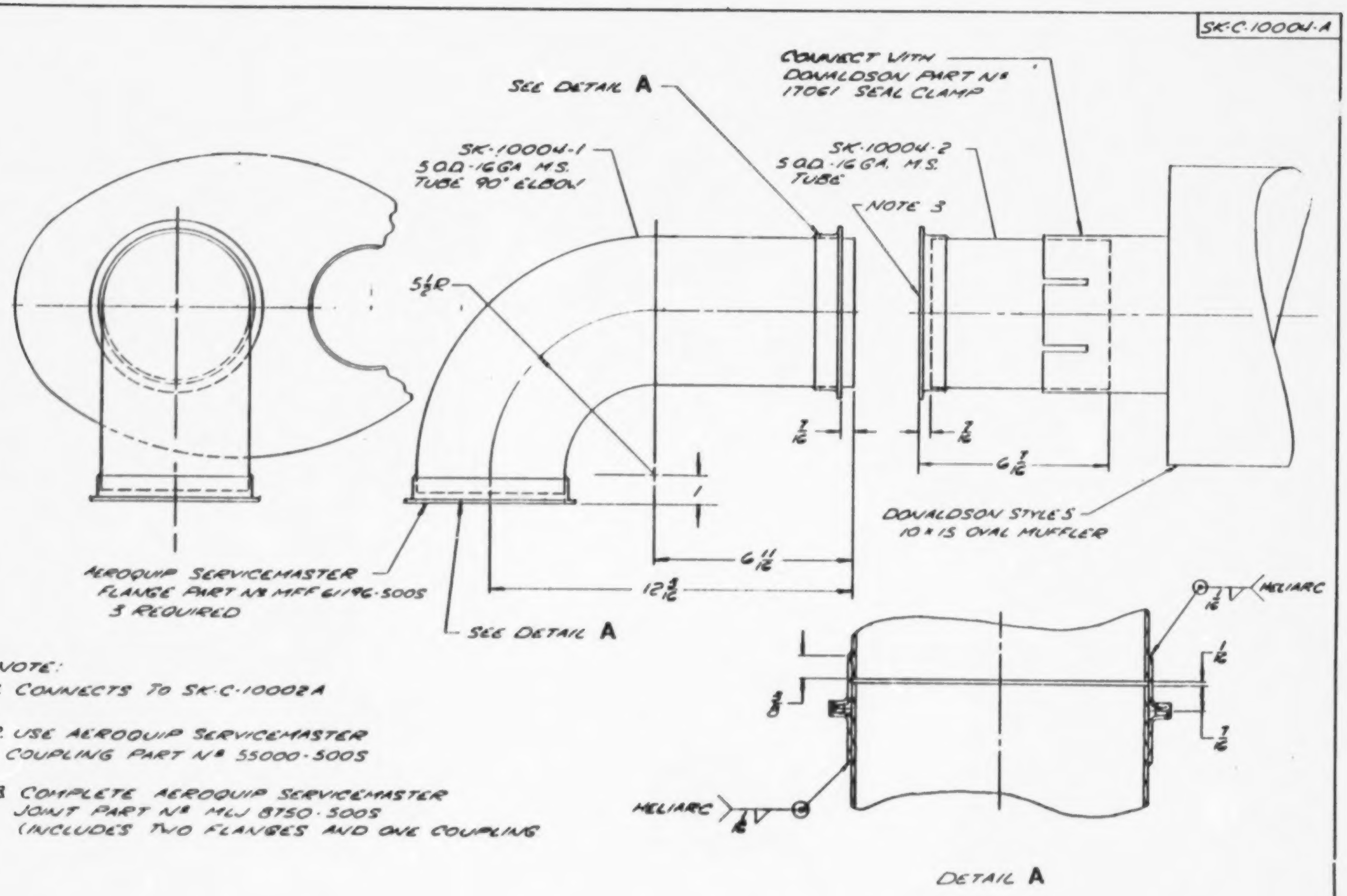
WHERE USED: FLXIBLE 111DC-D061

TRI-MET 4012 S.E. 17TH AVENUE
PORTLAND, OREGON 97202

TITLE: MUFFLER JACKET ASS'Y

DRAWING NUMBER: SK-A-10003 A

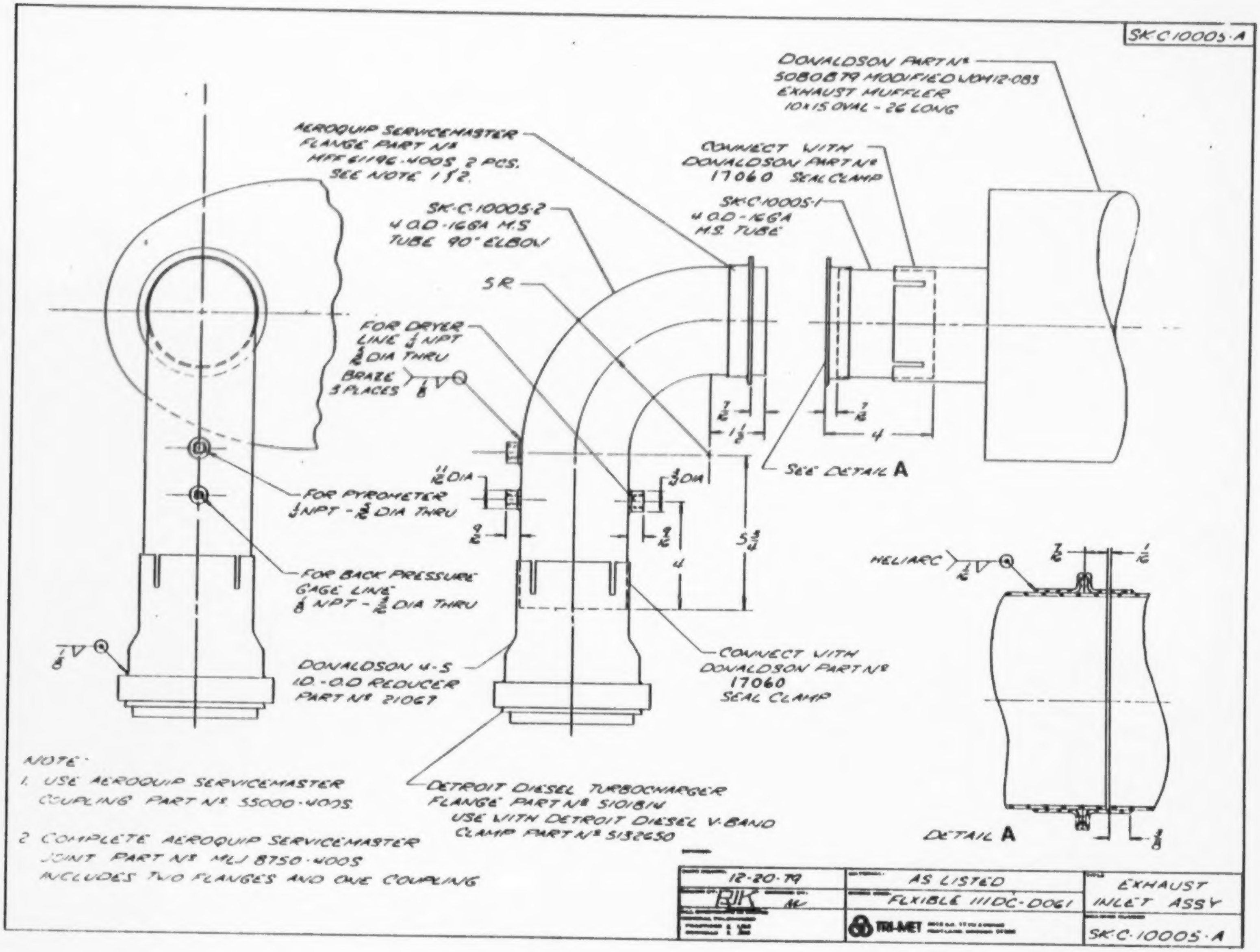
SK-C-10004-A


SEE DETAIL A
CONNECT WITH DONALDSON PART Nº 17061 SEAL CLAMP
SK-10004-1 5 O.D.-16GA. M.S. TUBE 90° ELBOW
SK-10004-2 5 O.D.-16GA. M.S. TUBE
NOTE 3
5½R
1
7/16
7/16
6 7/16
6 11/16
12 3/16
DONALDSON STYLE S 10 × 15 OVAL MUFFLER
AEROQUIP SERVICEMASTER FLANGE PART Nº MFF 61196-500S 3 REQUIRED
SEE DETAIL A
HELIARC
1/16
1/16
7/16
3/8
HELIARC
1/16
DETAIL A

NOTE:

1. CONNECTS TO SK-C-10002A
2. USE AEROQUIP SERVICEMASTER COUPLING PART Nº 55000-500S
3. COMPLETE AEROQUIP SERVICEMASTER JOINT PART Nº MLJ 8750-500S (INCLUDES TWO FLANGES AND ONE COUPLING

12-18-79	AS LISTED	LOWER EXHAUST ASSY
RJK	FLXIBLE 111DC-0061	
	TRI-MET	SK-C-10004-A

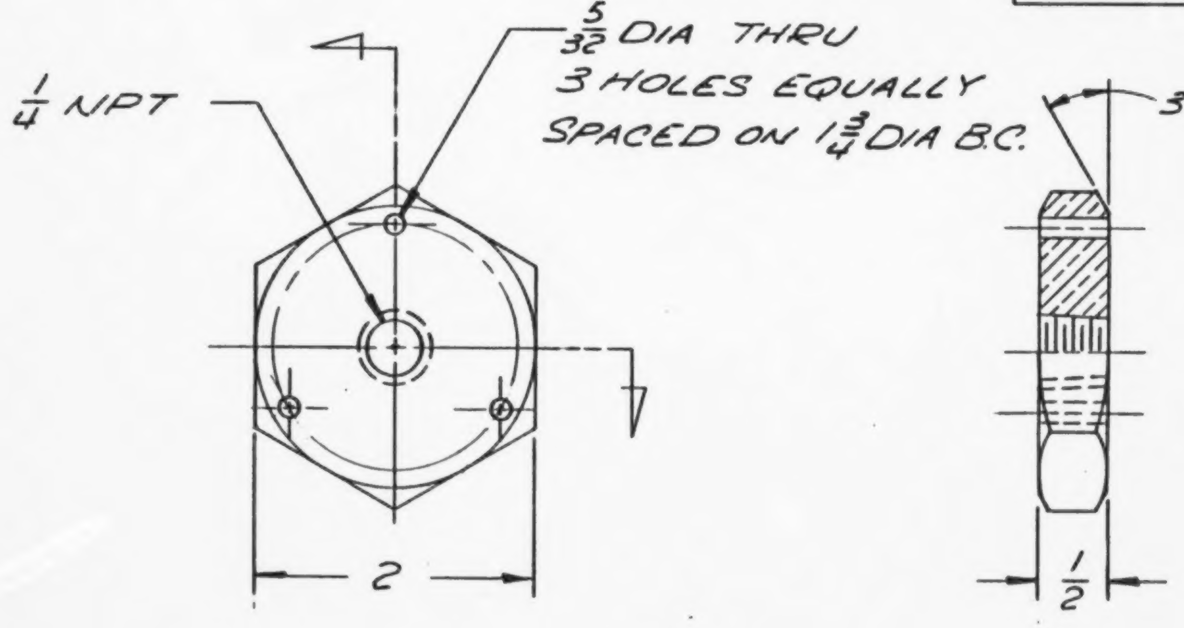

SK-C-10005-A
DONALDSON PART Nº 5080B79 MODIFIED VOH12-083 EXHAUST MUFFLER 10x15 OVAL - 26 LONG
AEROQUIP SERVICEMASTER FLANGE PART Nº MFF 61196-400S 2 PCS. SEE NOTE 1 & 2.
CONNECT WITH DONALDSON PART Nº 17060 SEAL CLAMP
SK-C-10005-1 4 O.D - 16GA M.S. TUBE
SK-C-10005-2 4 O.D - 16GA M.S TUBE 90° ELBOW
5 R.
FOR DRYER LINE $\frac{1}{4}$ NPT $\frac{5}{16}$ DIA THRU
BRAZE 3 PLACES $\frac{1}{8}$
$\frac{7}{16}$
$1\frac{1}{2}$
$\frac{7}{16}$
4
SEE DETAIL A
$\frac{11}{16}$ DIA
$\frac{3}{4}$ DIA
FOR PYROMETER $\frac{1}{4}$ NPT - $\frac{5}{16}$ DIA THRU
$\frac{9}{16}$
$\frac{9}{16}$
$5\frac{3}{4}$
4
FOR BACK PRESSURE GAGE LINE $\frac{1}{8}$ NPT - $\frac{3}{16}$ DIA THRU
$\frac{1}{8}$
DONALDSON 4-5 I.D. - O.D REDUCER PART Nº 21067
CONNECT WITH DONALDSON PART Nº 17060 SEAL CLAMP
DETROIT DIESEL TURBOCHARGER FLANGE PART Nº 5101814 USE WITH DETROIT DIESEL V-BAND CLAMP PART Nº 5132650
HELIARC $\frac{1}{16}$
$\frac{7}{16}$
$\frac{1}{16}$
$\frac{3}{8}$
DETAIL A

NOTE:

1. USE AEROQUIP SERVICEMASTER COUPLING PART Nº 55000-400S.
2. COMPLETE AEROQUIP SERVICEMASTER JOINT PART Nº MLJ 8750-400S INCLUDES TWO FLANGES AND ONE COUPLING

12-20-79
RJK
AS LISTED
FLXIBLE 111DC-0061
TRI-MET
EXHAUST INLET ASSY
SK-C-10005-A

SK-A-10007

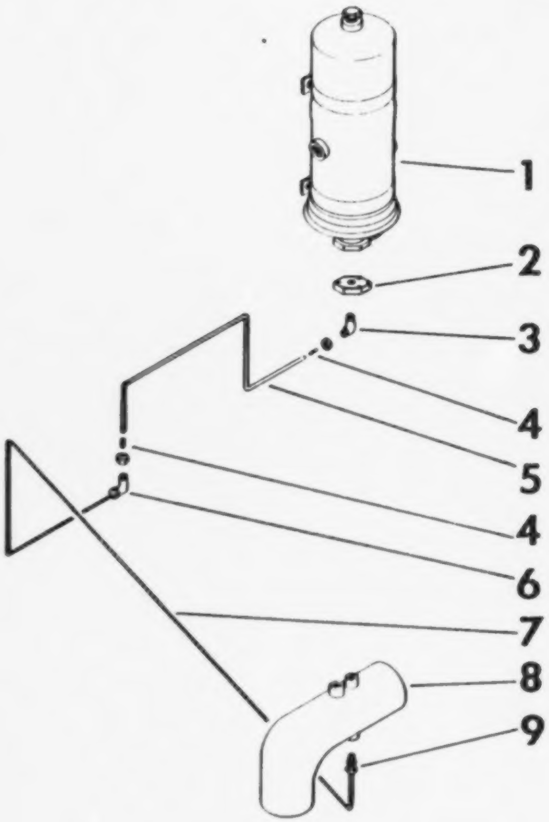

$\frac{1}{4}$ NPT
$\frac{5}{32}$ DIA THRU
3 HOLES EQUALLY
SPACED ON $1\frac{3}{4}$ DIA B.C.
30°
2
$\frac{1}{2}$

NOTE
INSTALL WITH 3
6-32 N.C. × $\frac{7}{8}$ SCREWS

REVISED:

DATE DRAWN: DEC 8, 1979	MATERIAL: BRASS 2" HEX STOCK	TITLE DRYER ADAPTER
DRAWN BY: RJK CHECKED BY:	WHERE USED: FLXIBLE 111DC-D061	
ALL DIMENSIONS IN INCHES GENERAL TOLERANCES FRACTIONS ± 1/64 DECIMALS ± .005	TRI-MET 4012 S.E. 17TH AVENUE PORTLAND, OREGON 97202	DRAWING NUMBER SK-A-10007

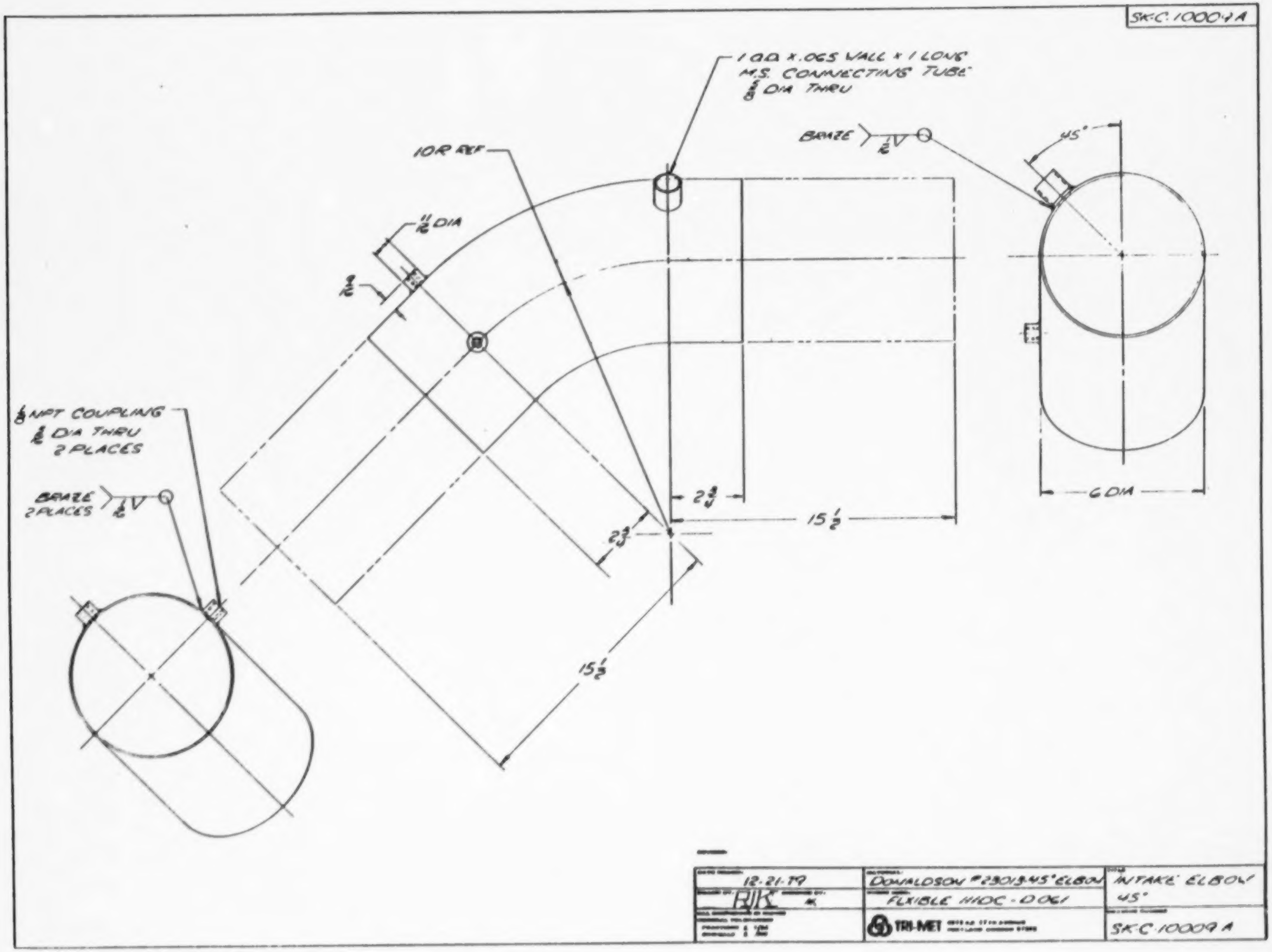
SK-A-10008-A



REF	PART NUMBER	DESCRIPTION
1	AD-2	Bendix Air Dryer
2	SK-A-10007	Adapter
3	269CA-6-4	Parker ¼" NPT Male Elbow
4	63PT-6-62	Parker Brass Insert
5	SAE J844B Type 3	3/8" OD Nylon Tube
6	165CA-6	Parker Union Elbow
7	SAE J844B Type 1	3/8" OD Copper Tube
8	SK-C-10005-2	90° Elbow
9	68CA-4-4	Parker ¼" NPT Male Connector

REVISED:

DATE DRAWN: JAN 4, 1980	MATERIAL: AS NOTED	TITLE DRYER-AIRLINE INST.
DRAWN BY: SPS CHECKED BY:	WHERE USED: FLXIBLE 111DC · D061	
ALL DIMENSIONS IN INCHES GENERAL TOLERANCES FRACTIONS ± 1/64 DECIMALS ± .005	TRI-MET 4012 S.E. 17TH AVENUE PORTLAND, OREGON 97202	DRAWING NUMBER SK-A-10008-A

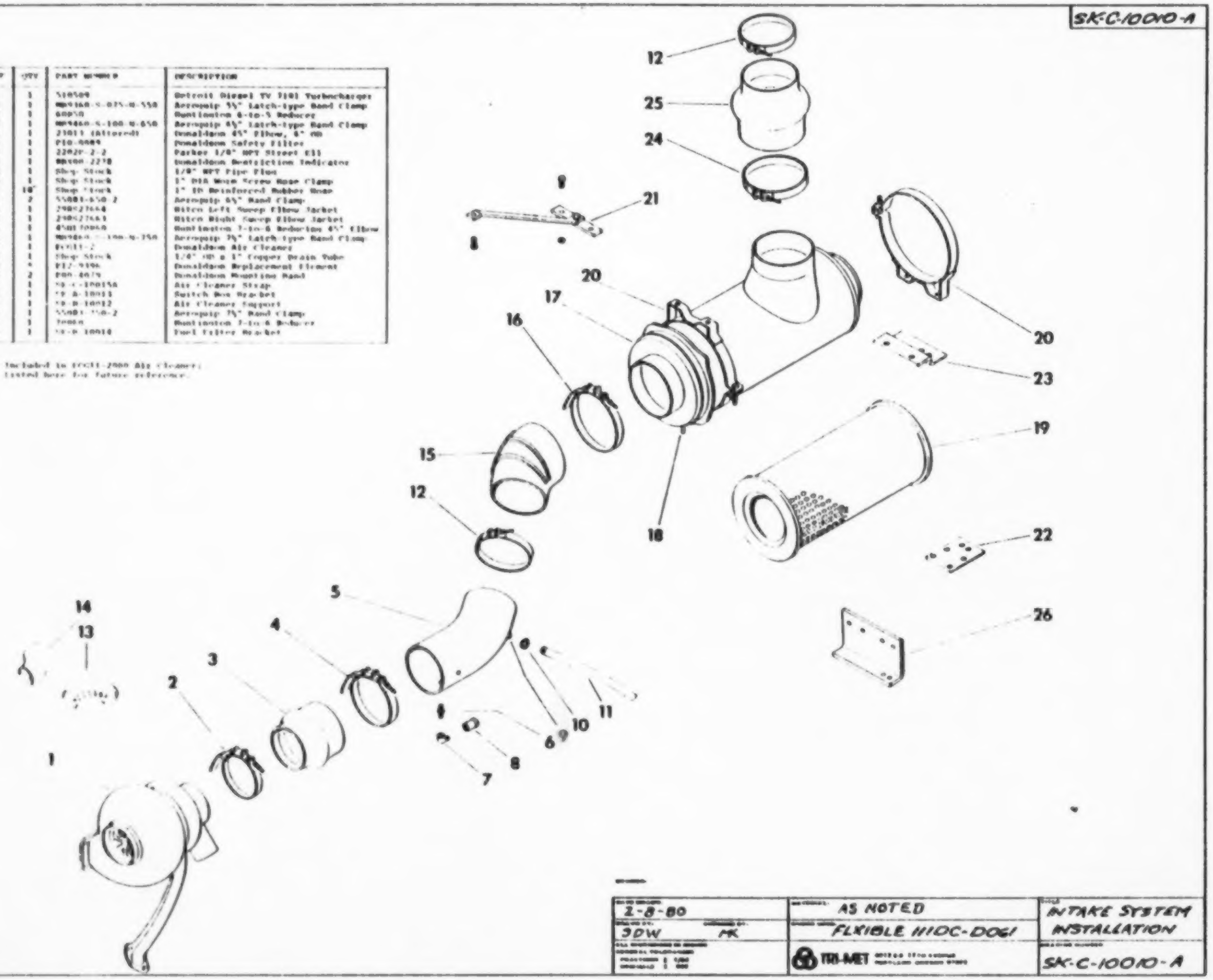

SK-C 10009A
1.00 O.D. x .065 WALL x 1 LONG
M.S. CONNECTING TUBE
5/8 DIA THRU
BRAZE 1/16
45°
10R REF
11/16 DIA
9/16
6 DIA
2 3/4
15 1/2
2 3/4
15 1/2
1/8 NPT COUPLING
5/16 DIA THRU
2 PLACES
BRAZE 2 PLACES 1/16
12-21-79
RJK
DONALDSON #23013 45° ELBOW
FLEXIBLE H10C-D061
TRI-MET
INTAKE ELBOW
45°
SK-C 10009 A

Reproduced from best available copy.

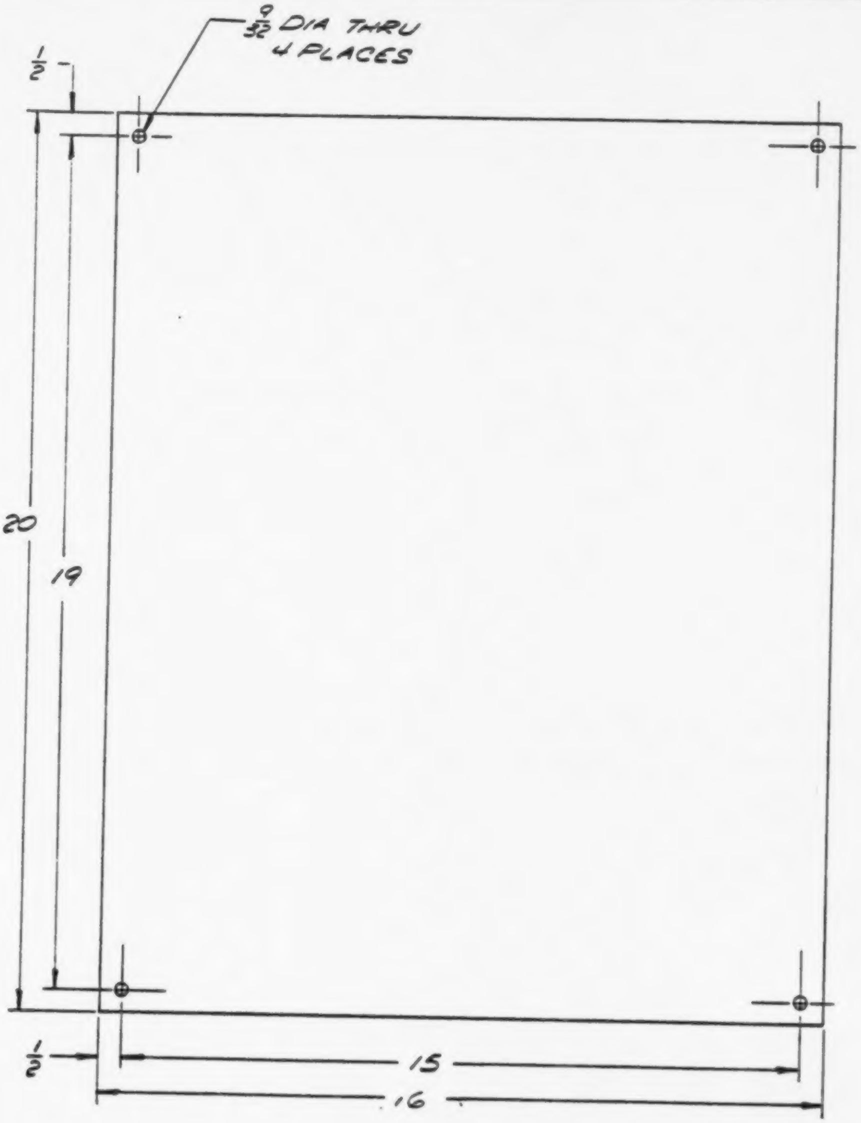
SK-C-10010-A

NO	QTY	PART NUMBER	DESCRIPTION
1	1	510509	Detroit Diesel TV 7101 Turbocharger
2	1	MB9160-S-075-N-550	Aeroquip 5½" Latch-type Band Clamp
3	1	60050	Huntington 6-to-5 Reducer
4	1	MB9460-S-100-N-650	Aeroquip 6½" Latch-type Band Clamp
5	1	23013 (Altered)	Donaldson 45° Elbow, 6" OD
6	1	P10-0009	Donaldson Safety Filter
7	1	2202P-2-2	Parker 1/8" NPT Street Ell
8	1	RBX00-2278	Donaldson Restriction Indicator
9	1	Shop Stock	1/8" NPT Pipe Plug
10	1	Shop Stock	1" DIA Worm Screw Hose Clamp
11	10"	Shop Stock	1" ID Reinforced Rubber Hose
12	2	55001-650-2	Aeroquip 6½" Band Clamp
13	1	2905273664	Hitco Left Sweep Elbow Jacket
14	1	2905273663	Hitco Right Sweep Elbow Jacket
15	1	45HT70060	Huntington 7-to-6 Reducing 45° Elbow
16	1	MB9460-S-100-N-750	Aeroquip 7½" Latch-type Band Clamp
17	1	ECG11-2	Donaldson Air Cleaner
18	1	Shop Stock	1/4" OD x 1" Copper Drain Tube
19	*	P12-9396	Donaldson Replacement Element
20	2	P00-8679	Donaldson Mounting Band
21	1	SK-C-10015A	Air Cleaner Strap
22	1	SK-A-10013	Switch Box Bracket
23	1	SK-B-10012	Air Cleaner Support
24	1	55001-750-2	Aeroquip 7½" Band Clamp
25	1	70060	Huntington 7-to-6 Reducer
26	1	SK-B-10010	Fuel Filter Bracket

* Included in ECG11-2000 Air Cleaner;
listed here for future reference.



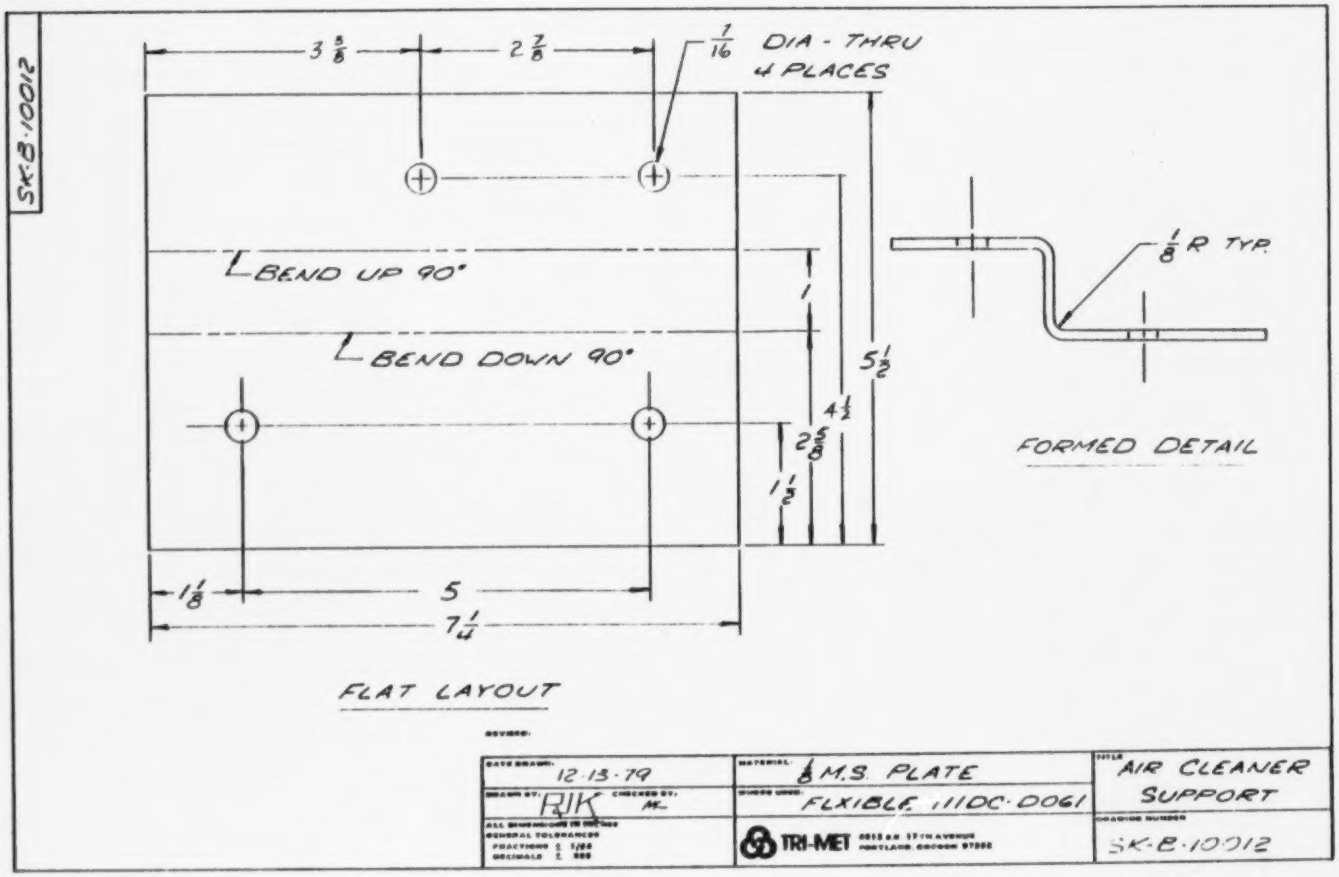
2-8-80
JDW
MK
AS NOTED
FLXIBLE 110C-D061
TRI-MET
INTAKE SYSTEM INSTALLATION
SK-C-10010-A



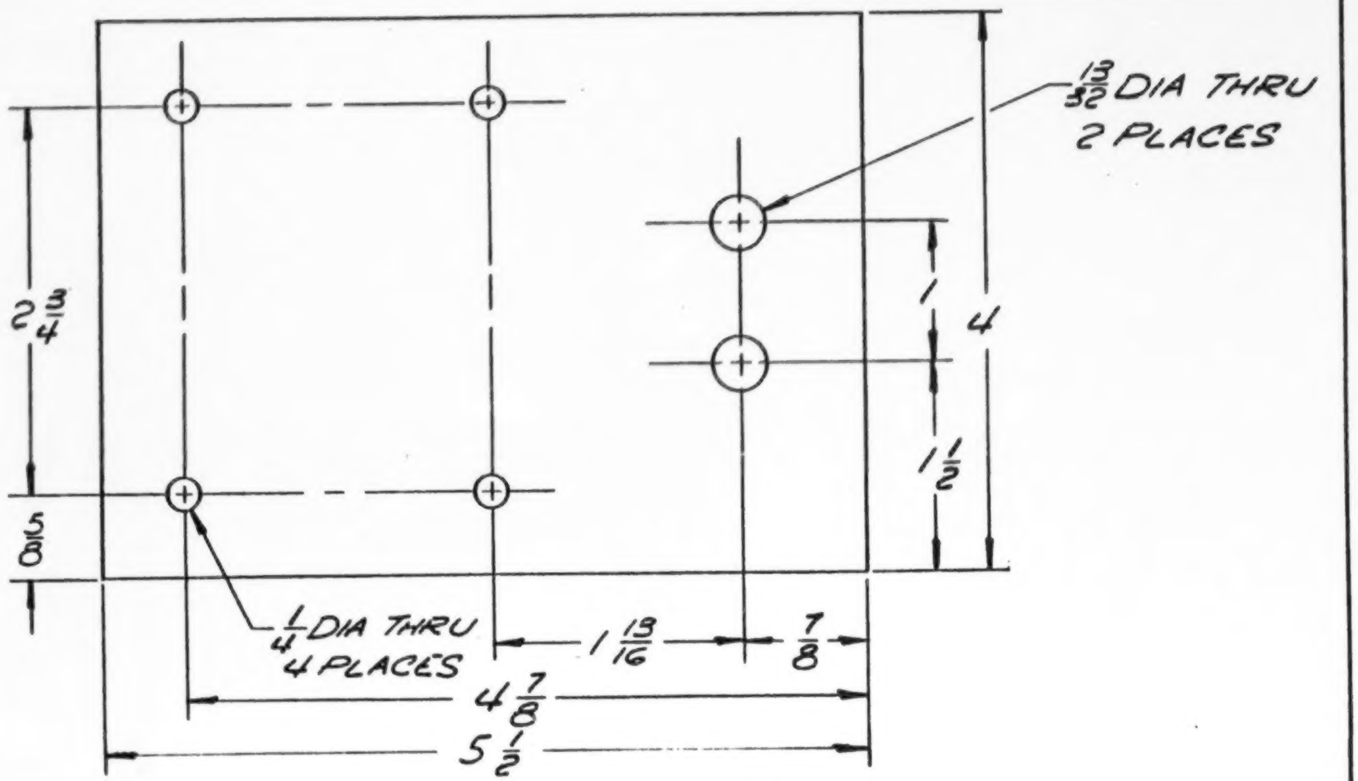
9/32 DIA THRU
4 PLACES
1/2
20
19
1/2
15
16

NOTE : PRIME BEFORE INST.

DEC 9, 1979	1/8 M.S. PLATE	FIREWALL BLANK
RJK AL	FLXIBLE 111DC·DOG1	
	TRI-MET	SK-B-10011


SK-B-10012
3 3/8
2 7/8
1/16 DIA - THRU
4 PLACES
BEND UP 90°
BEND DOWN 90°
1
5 1/2
4 1/2
2 5/8
1 1/2
1 1/8
5
7 1/4
1/8 R TYP.
FORMED DETAIL
FLAT LAYOUT
REVISED:
DATE DRAWN: 12-13-79
DRAWN BY: RJK
CHECKED BY: M
MATERIAL: 1/8 M.S. PLATE
WHERE USED: FLXIBLE 111DC-0061
TRI-MET
TITLE AIR CLEANER SUPPORT
DRAWING NUMBER SK-B-10012

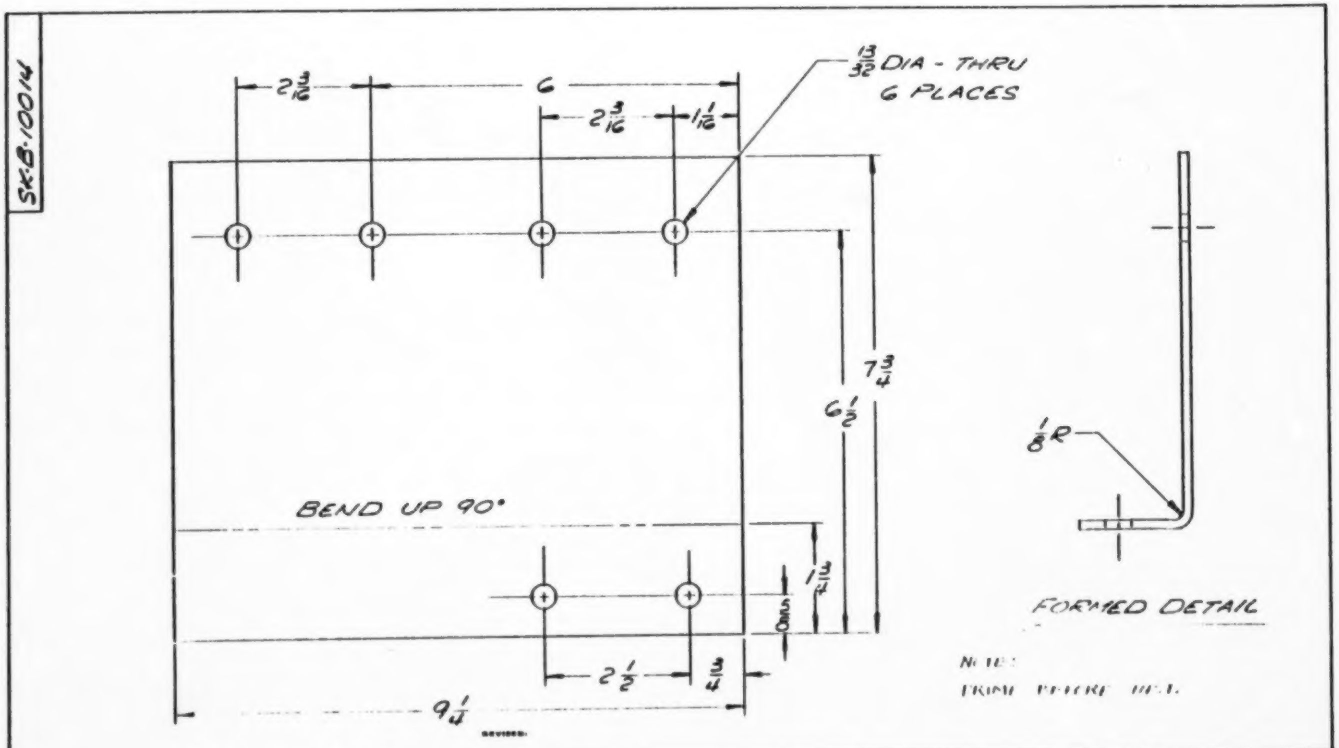
SK-A-10003



$\frac{13}{32}$ DIA THRU
2 PLACES
$\frac{1}{4}$ DIA THRU
4 PLACES
$2\frac{3}{4}$
$\frac{5}{8}$
1
$1\frac{1}{2}$
4
$1\frac{13}{16}$
$\frac{7}{8}$
$4\frac{7}{8}$
$5\frac{1}{2}$

REVISED:

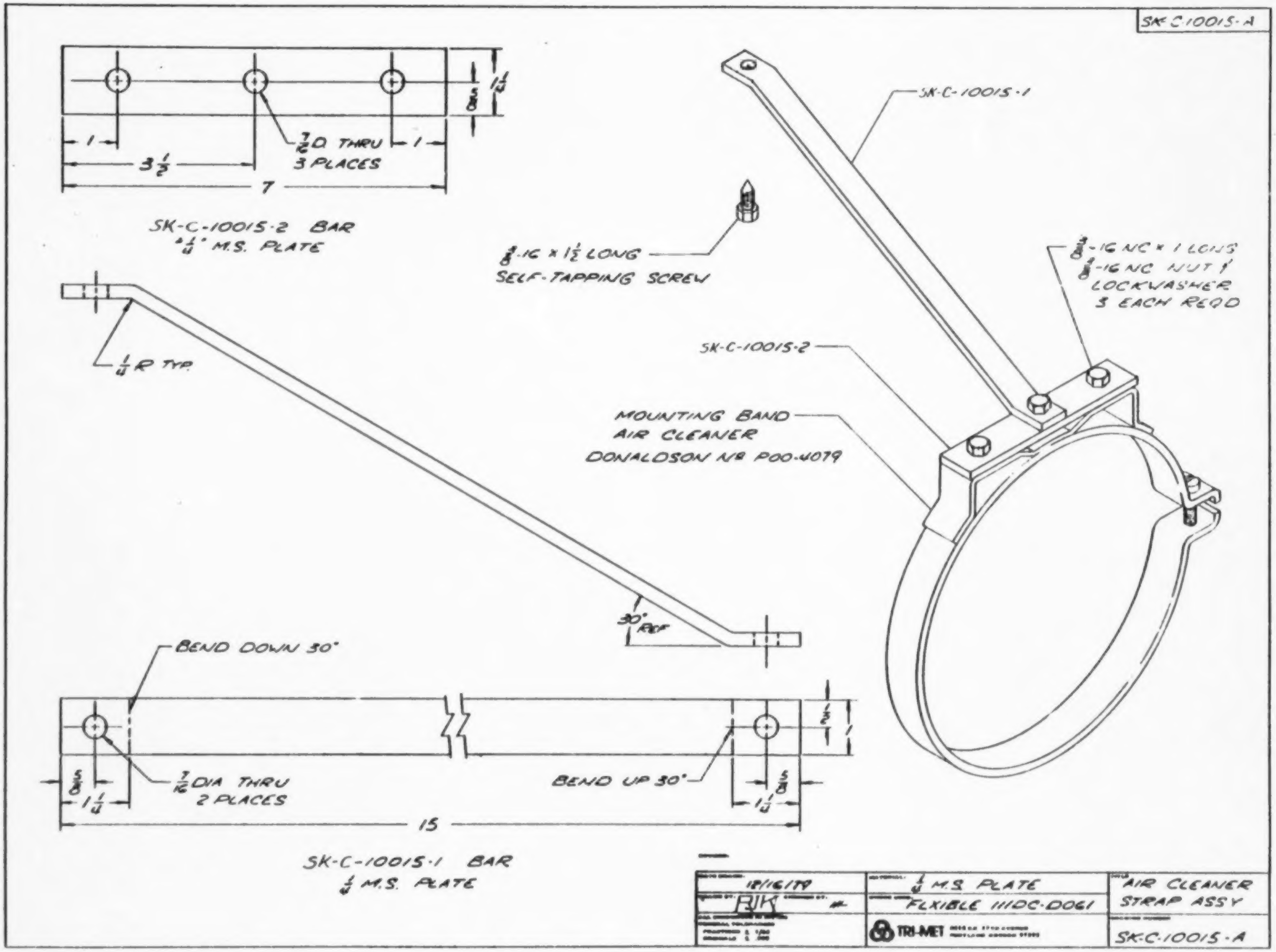
DATE DRAWN: 12/10/79	MATERIAL: $\frac{1}{8}$ M.S. PLATE	TITLE SWITCH BOX BRACKET
DRAWN BY: RJK CHECKED BY:	WHERE USED: FLXIBLE 111DC-D061	
ALL DIMENSIONS IN INCHES GENERAL TOLERANCES FRACTIONS ± 1/64 DECIMALS ± .005	TRI-MET 4012 S.E. 17TH AVENUE PORTLAND, OREGON 97202	DRAWING NUMBER SK-A-10013

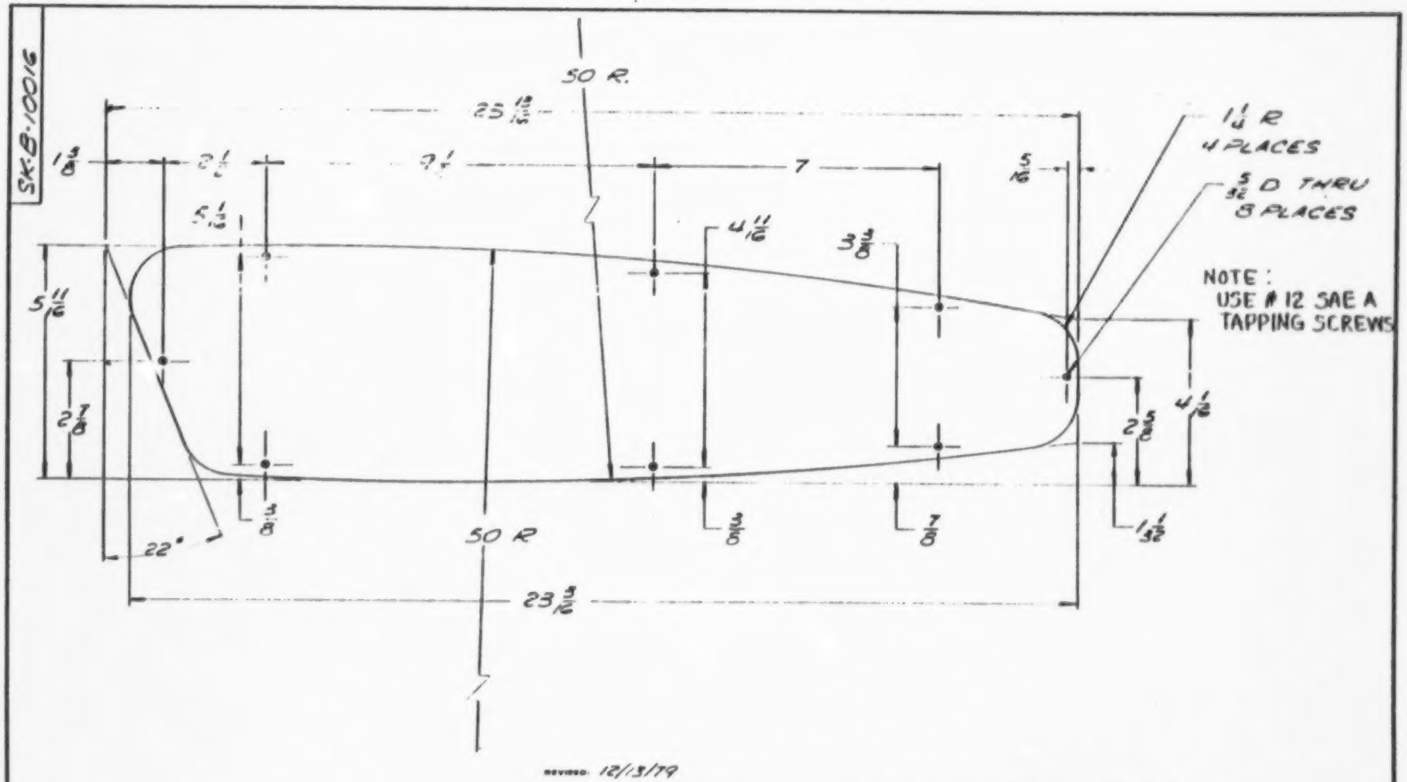

SK-B-10014
$2\frac{3}{16}$
6
$2\frac{3}{16}$
$1\frac{1}{16}$
$\frac{13}{32}$ DIA - THRU
6 PLACES
$7\frac{3}{4}$
$6\frac{1}{2}$
$\frac{1}{8}$R
BEND UP 90°
$1\frac{3}{4}$
$\frac{5}{8}$
$2\frac{1}{2}$
$\frac{3}{4}$
$9\frac{1}{4}$
FORMED DETAIL
FLAT LAYOUT

NOTE:
PRIME BEFORE INST.

REVISED:

DATE DRAWN: 12·13·79	MATERIAL: $\frac{1}{8}$ M.S PLATE	TITLE FUEL FILTER BRACKET
DRAWN BY: RJK CHECKED BY: *	WHERE USED: FLXIBLE 111DC 0361	
ALL DIMENSIONS IN INCHES GENERAL TOLERANCES FRACTIONS ± 1/64 DECIMALS ± .005	TRI-MET 4012 S.E. 17TH AVENUE PORTLAND, OREGON 97202	DRAWING NUMBER SK-B-10014


SK-C-10015-A
SK-C-10015-2 BAR
$\frac{1}{4}$" M.S. PLATE
$\frac{7}{16}$ D. THRU
3 PLACES
1
$3\frac{1}{2}$
7
$\frac{5}{8}$
$1\frac{1}{4}$
$\frac{3}{8}$-16 × $1\frac{1}{2}$ LONG
SELF-TAPPING SCREW
SK-C-10015-1
$\frac{3}{8}$-16 NC × 1 LONG
$\frac{3}{8}$-16 NC NUT &
LOCKWASHER
3 EACH REQD
SK-C-10015-2
MOUNTING BAND
AIR CLEANER
DONALDSON № P00-4079
$\frac{1}{4}$ R TYP.
30° REF
BEND DOWN 30°
BEND UP 30°
$\frac{7}{16}$ DIA THRU
2 PLACES
$\frac{5}{8}$
$1\frac{1}{4}$
$\frac{1}{2}$
1
15
SK-C-10015-1 BAR
$\frac{1}{4}$ M.S. PLATE
12/16/79
RJK
$\frac{1}{4}$ M.S. PLATE
FLXIBLE 111DC-D061
TRI-MET
AIR CLEANER
STRAP ASSY
SK-C-10015-A


SK·B·10016
50 R.
$25\frac{13}{16}$
$1\frac{3}{8}$
$2\frac{1}{2}$
$9\frac{1}{2}$
7
$\frac{5}{16}$
$1\frac{1}{4}$ R
4 PLACES
$\frac{5}{32}$ D THRU
8 PLACES
NOTE :
USE # 12 SAE A
TAPPING SCREWS
$5\frac{1}{16}$
$4\frac{11}{16}$
$3\frac{3}{8}$
$5\frac{11}{16}$
$2\frac{7}{8}$
$2\frac{5}{8}$
$4\frac{1}{16}$
$\frac{3}{8}$
50 R
$\frac{3}{8}$
$\frac{7}{8}$
$1\frac{1}{32}$
22°
$23\frac{3}{16}$

REVISED: 12/13/79

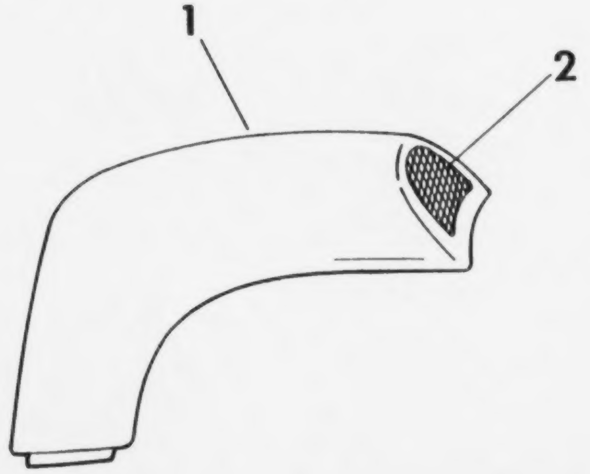
DATE DRAWN: 10/5/79
DRAWN BY: RJK
CHECKED BY: MK
ALL DIMENSIONS IN INCHES
GENERAL TOLERANCES
FRACTIONS ± 1/64
DECIMALS ± .005

MATERIAL: 1/8 POLYPROPYLENE SHEET
HAIRCELL FINISH, BLACK
WHERE USED: FLXIBLE 111DC-D061

TRI-MET 4012 S.E. 17TH AVENUE
PORTLAND, OREGON 97202

TITLE: INTAKE
COWL BLANK
DRAWING NUMBER: SK·B-10016

SK-A-10017-A



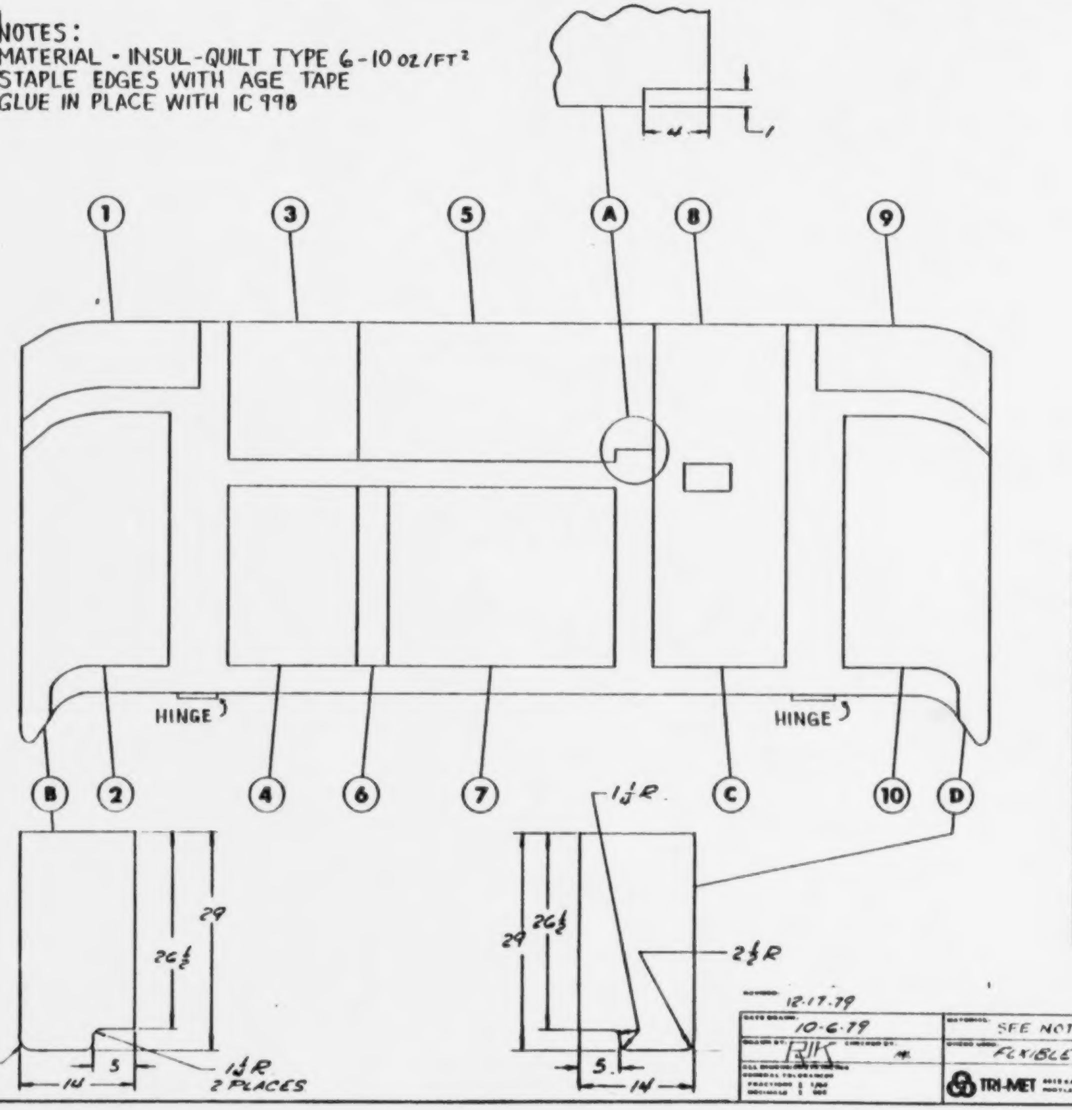
REF	PART NO.	MATERIAL
2	SK-A-10017-2	SS WIRE SCRN
1	SK-A-10017-1	FIBERGLASS

REVISED:

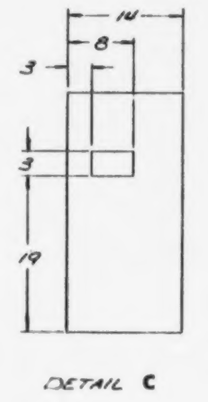
DATE DRAWN: JAN 7, 1979	MATERIAL: AS NOTED	TITLE HOLLOWAY SNORKLE
DRAWN BY: SPS CHECKED BY: ᴍᴄ	WHERE USED: FLXIBLE 111DC - D061	
ALL DIMENSIONS IN INCHES GENERAL TOLERANCES FRACTIONS ± 1/64 DECIMALS ± .005	TRI-MET 4012 S.E. 17TH AVENUE PORTLAND, OREGON 97202	DRAWING NUMBER SK-A-10017-A

SK-C-10018A

NOTES:
MATERIAL - INSUL-QUILT TYPE 6-10 OZ/FT²
STAPLE EDGES WITH AGE TAPE
GLUE IN PLACE WITH IC 998



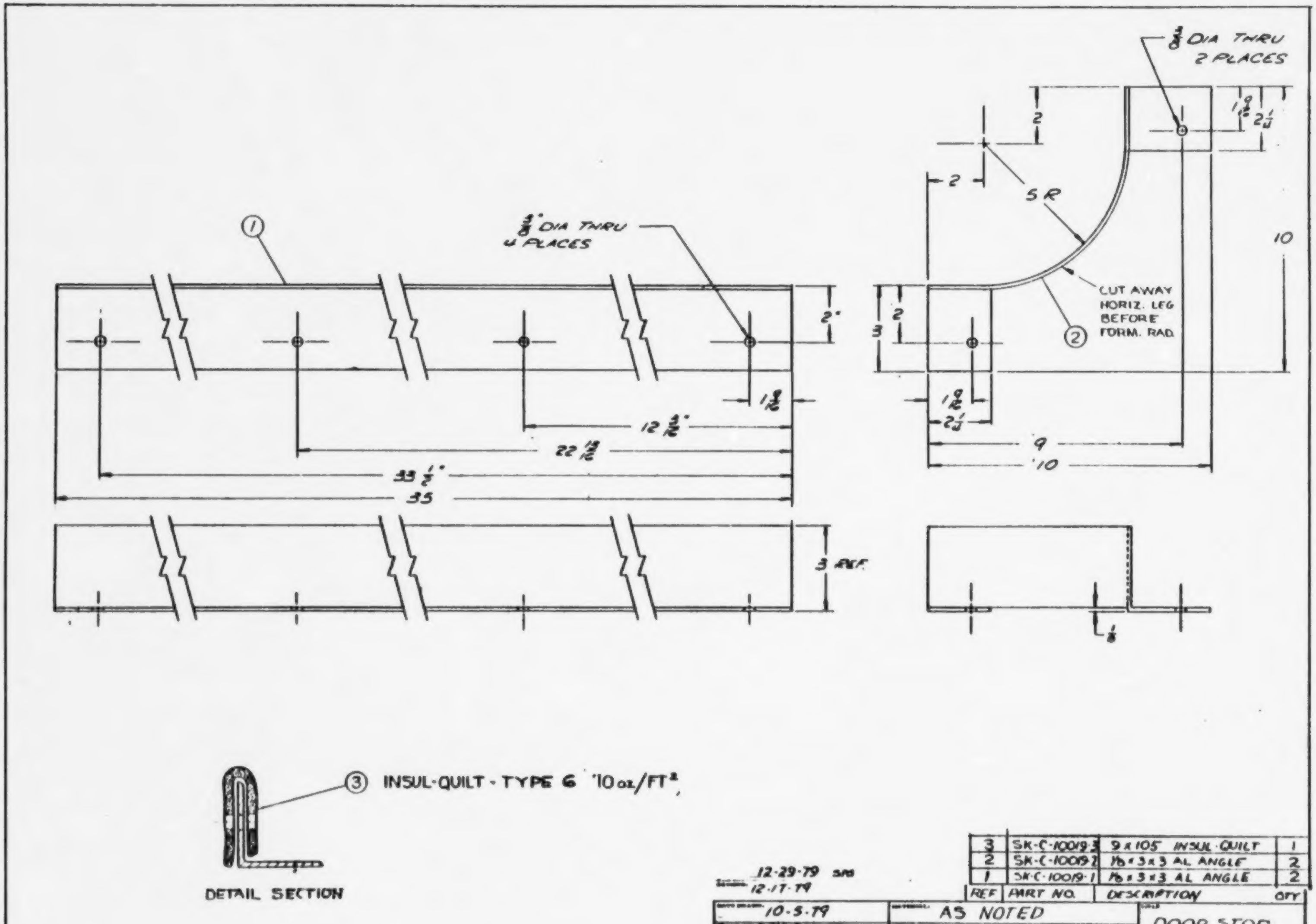
1
3
5
A
8
9
4
1
HINGE
HINGE
B
2
4
6
7
C
10
D
29
26½
2½R
5
14
1½R 2 PLACES
1½R
29
26½
2½R
5.
14



14
8
3
3
19
DETAIL C

DASH	PART NO.	SIZE
1	SK-C-10018-1	7 x 20
2	SK-C-10018-2	29 x 14
3	SK-C-10018-3	14 x 14
4	SK-C-10018-4	19½ x 14
5	SK-C-10018-5	14 x 30½
6	SK-C-10018-6	17½ x 3
7	SK-C-10018-7	19½ x 24
8	SK-C-10018-8	35 x 13½
9	SK-C-10018-9	7 x 20
10	SK-C-10018-10	29 x 14

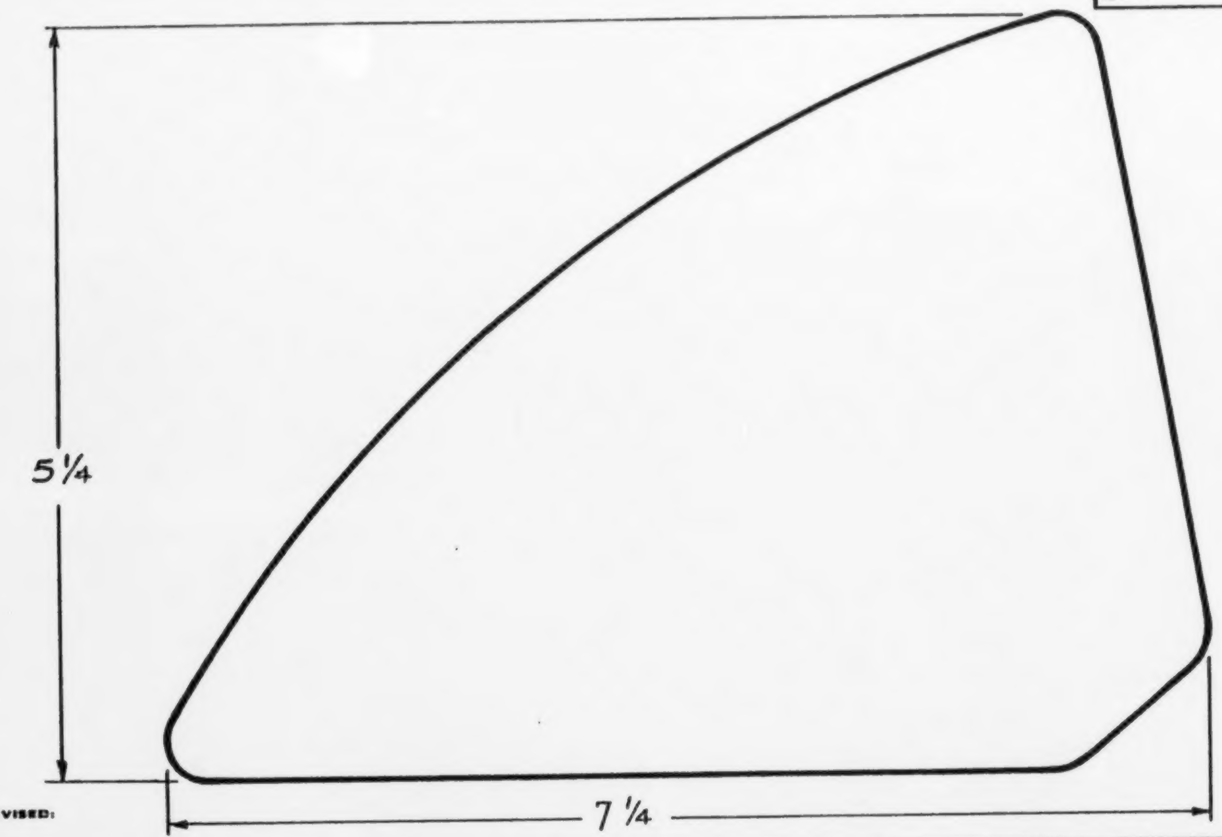
REVISED 12-17-79
DATE DRAWN 10-6-79
DRAWN BY RIK
MATERIAL SEE NOTES
FLEXIBLE 1110C-0021
TRI-MET
REAR DOOR PADDING
SK-C-10018A


3/8 DIA THRU
2 PLACES
3/8" DIA THRU
4 PLACES
①
②
③ INSUL-QUILT - TYPE 6 10 oz/FT²
CUT AWAY
HORIZ. LEG
BEFORE
FORM. RAD.
5 R
2
2
10
3
2
1 9/16
2 1/4
9
10
2"
1 9/16
12 3/16"
22 13/16
33 1/2"
35
3 REF.
1/8
DETAIL SECTION

REF	PART NO.	DESCRIPTION	QTY
3	SK-C-10019-3	9 x 105 INSUL-QUILT	1
2	SK-C-10019-2	1/16 x 3 x 3 AL ANGLE	2
1	SK-C-10019-1	1/16 x 3 x 3 AL ANGLE	2

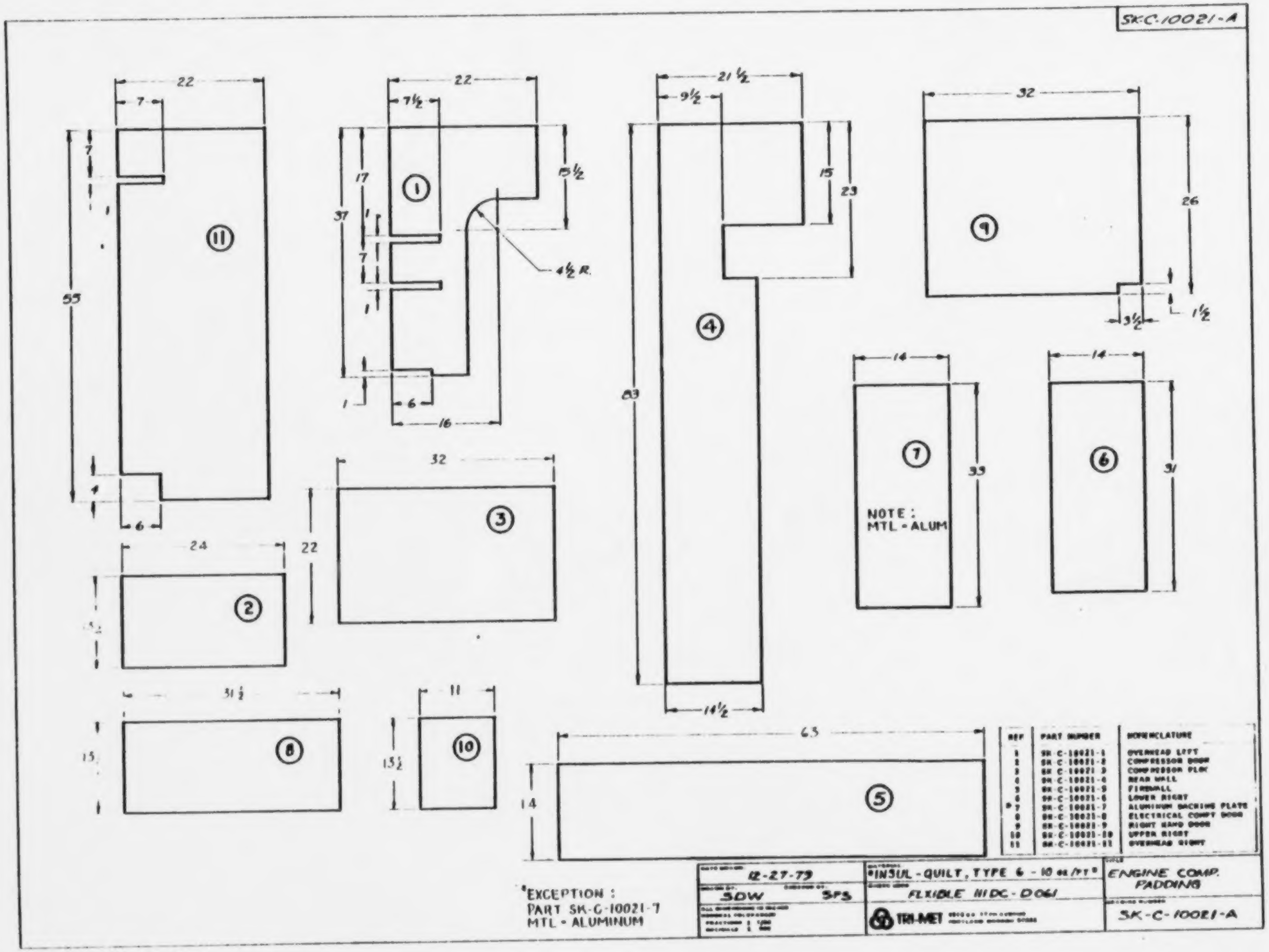
12-29-79 SPB
12-17-79
10-5-79
RJK
AS NOTED
FLXIBLE 111DC-D061
TRI-MET
DOOR STOP
SK-C-10019-A

SK-A-10020



REVISED:

DATE DRAWN: 12-8-79	MATERIAL: N/A	TITLE SNORKLE TEMPLATE
DRAWN BY: SDW CHECKED BY: SPS	WHERE USED: FLXIBLE 111DC-D061	
ALL DIMENSIONS IN INCHES GENERAL TOLERANCES FRACTIONS ± 1/64 DECIMALS ± .005	TRI-MET 4012 S.E. 17TH AVENUE PORTLAND, OREGON 97202	DRAWING NUMBER SK-A-10020

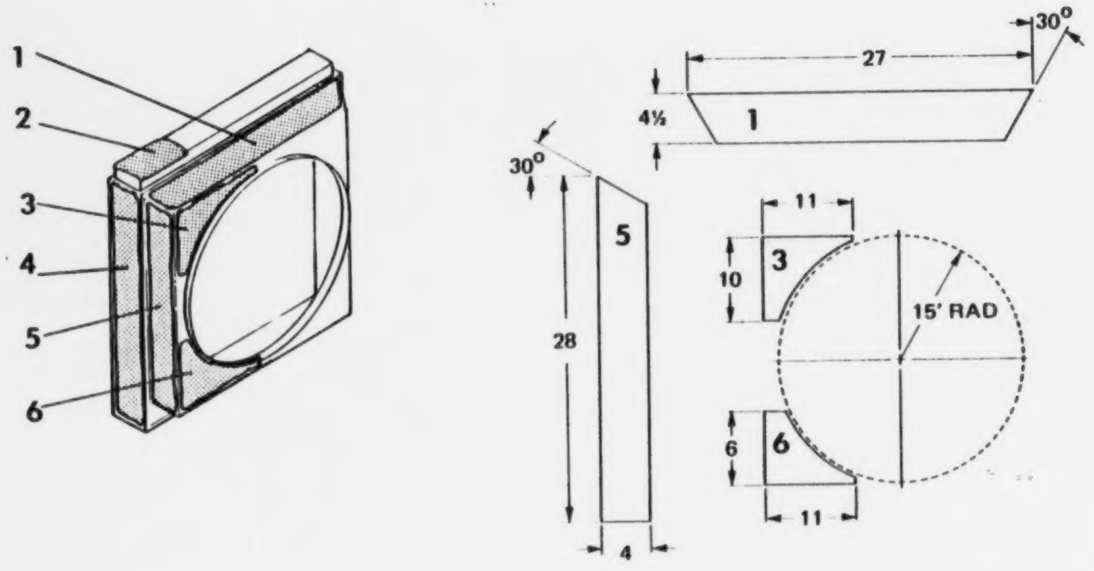

SK-C-10021-A
①
②
③
④
⑤
⑥
⑦
⑧
⑨
⑩
⑪
22
7
55
4
6
7½
17
37
7
1
15½
4½ R.
6
16
32
24
31½
15
11
13½
21½
9½
15
23
83
14½
65
14
26
3½
1½
33
31
NOTE :
MTL - ALUM

REF	PART NUMBER	NOMENCLATURE
1	SK-C-10021-1	OVERHEAD LEFT
2	SK-C-10021-2	COMPRESSOR DOOR
3	SK-C-10021-3	COMPRESSOR FLR
4	SK-C-10021-4	REAR WALL
5	SK-C-10021-5	FIREWALL
6	SK-C-10021-6	LOWER RIGHT
*7	SK-C-10021-7	ALUMINUM BACKING PLATE
8	SK-C-10021-8	ELECTRICAL COMPT DOOR
9	SK-C-10021-9	RIGHT HAND DOOR
10	SK-C-10021-10	UPPER RIGHT
11	SK-C-10021-11	OVERHEAD RIGHT

*EXCEPTION :
PART SK-C-10021-7
MTL - ALUMINUM

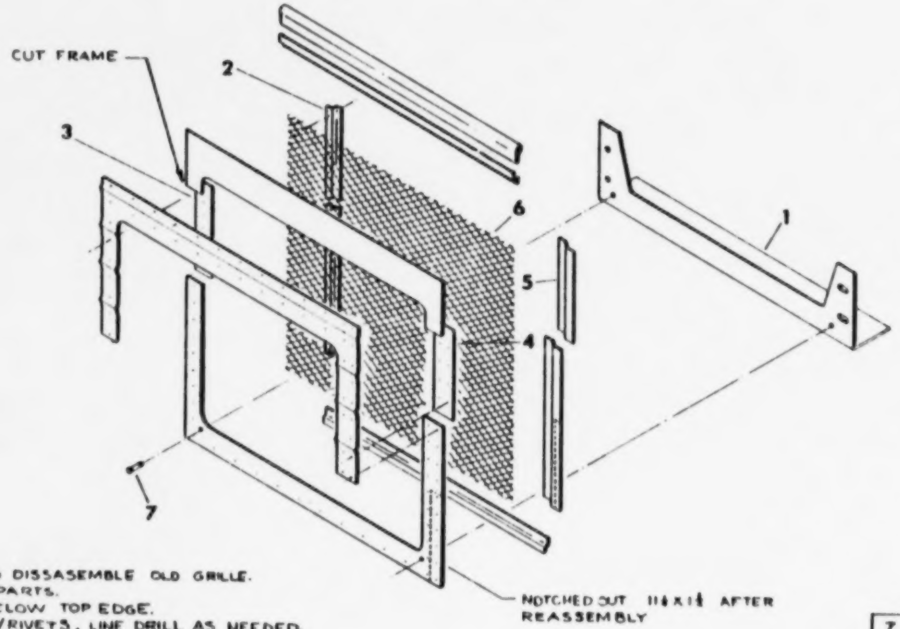
12-27-79
SDW SPS
*INSUL-QUILT, TYPE 6 - 10 oz/FT²
FLXIBLE II IDC-D061
TRI-MET
ENGINE COMP.
PADDING
SK-C-10021-A

SK-C10022-A


1
2
3
4
5
6
30°
27
4½
1
30°
5
28
4
11
10
3
15' RAD
6
6
11

REF	PART NUMBER	OVERALL DIMENSIONS
1	SK-B-10022-1	4½ x 27
2	SK-B-10022-2	6 x 9
3	SK-B-10022-3	10 x 11
4	SK-B-10022-4	6 x 25
5	SK-B-10022-5	4 x 28
6	SK-B-10022-6	6 x 11

2/11/80
SRS
INSUL QUILT. TYPE 6-10oz/FT²
FLXIBLE 111DC-D061
TRI-MET
RADIATOR
PADDING
SK-C10022-A

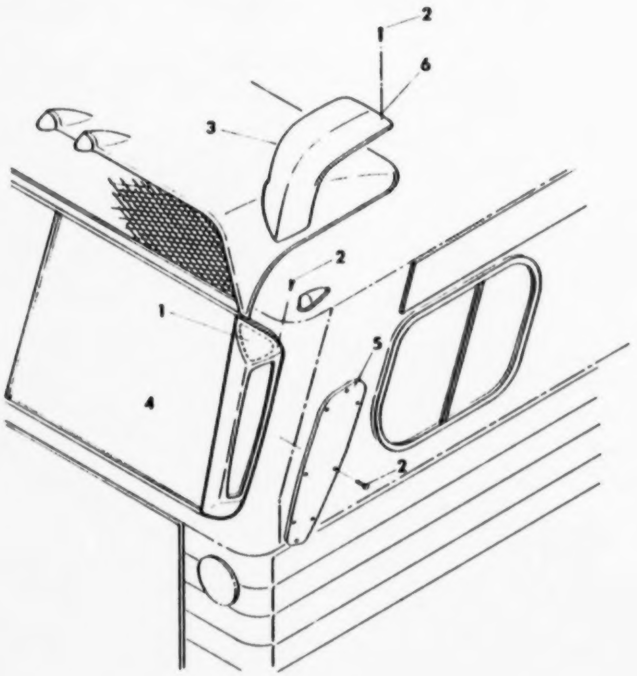


STEPS:
1. REMOVE RIVETS AND DISSASEMBLE OLD GRILLE.
2 FABRICATE NEW PARTS.
3 CUT FRAME 6" BELOW TOP EDGE.
4 REASSEMBLE W/RIVETS, LINE DRILL AS NEEDED.
5 CUT NOTCH IN LOWER R.H CORNER.
6 'ISTALL GRILLE AND LINE DRILL THRU AND INTO GRILLE SUPPORT (SK·B·10023). TAP ¼" · 20 NC

REF	PART NO	DESCRIPTION	Q'TY
7	SK·C·10023·6	1½ x ¼ · 20 NC	2
6	SK·C·10023·5	1 x 2 DIAMOND MS EXP MESH 31 x 32½	1
5	SK·C·10023-4	16 GA AL 10½ x 3½	1
4	SK·C·10023-3	16 GA AL 11 x 3½	1
3	SK·C·10023·2	16 GA AL. 11 x 2	1
2	SK·C·10023·1	16 GA AL 10½ x 2	1
1	SK B·10023	GRILLE SUPPORT	1

1/4/80
SPS MK
AS NOTED
FLXIBLE 111DC·D061
TRI-MET
REBUILT GRILLE
SK·C·10023·A

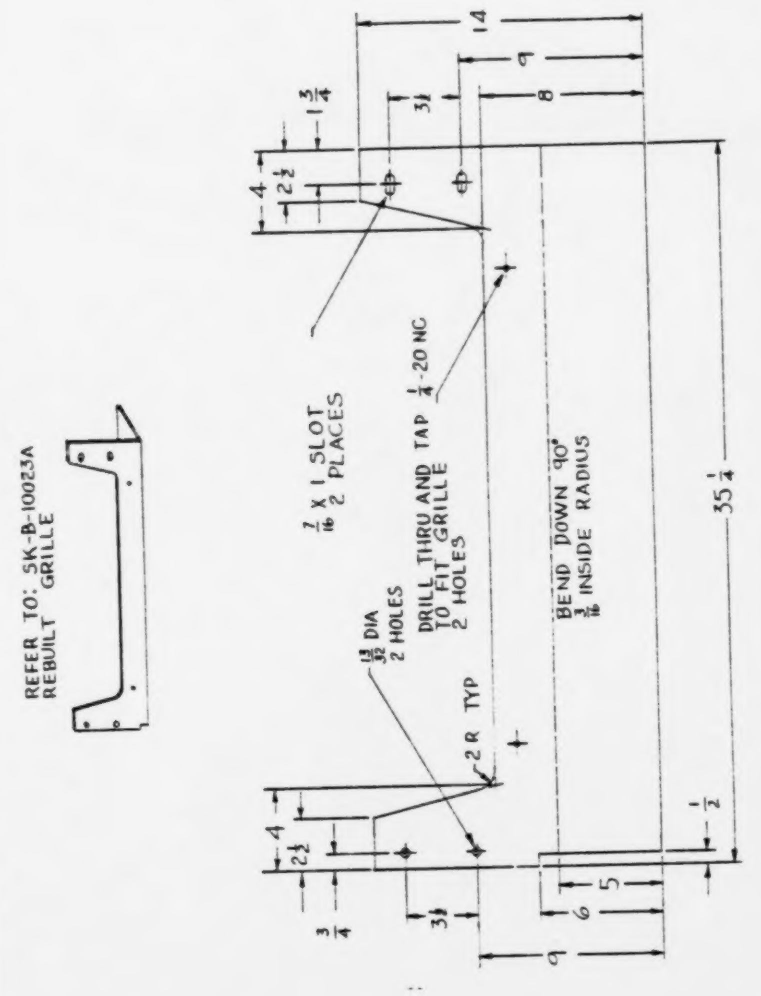
SK-C-0024-A



REF	PART NUMBER	NOMENCLATURE
1	SR-A-10020	SNORKLE TEMPLATE
2		SHEET METAL SCREWS
3	SR-A-10017A	[illegible] SNORKLE
4		EXISTING INTAKE COWL
5	SR-B-10016	INTAKE COWL BLANK
6	SR-A-10017-2	SS WIRE SCREEN

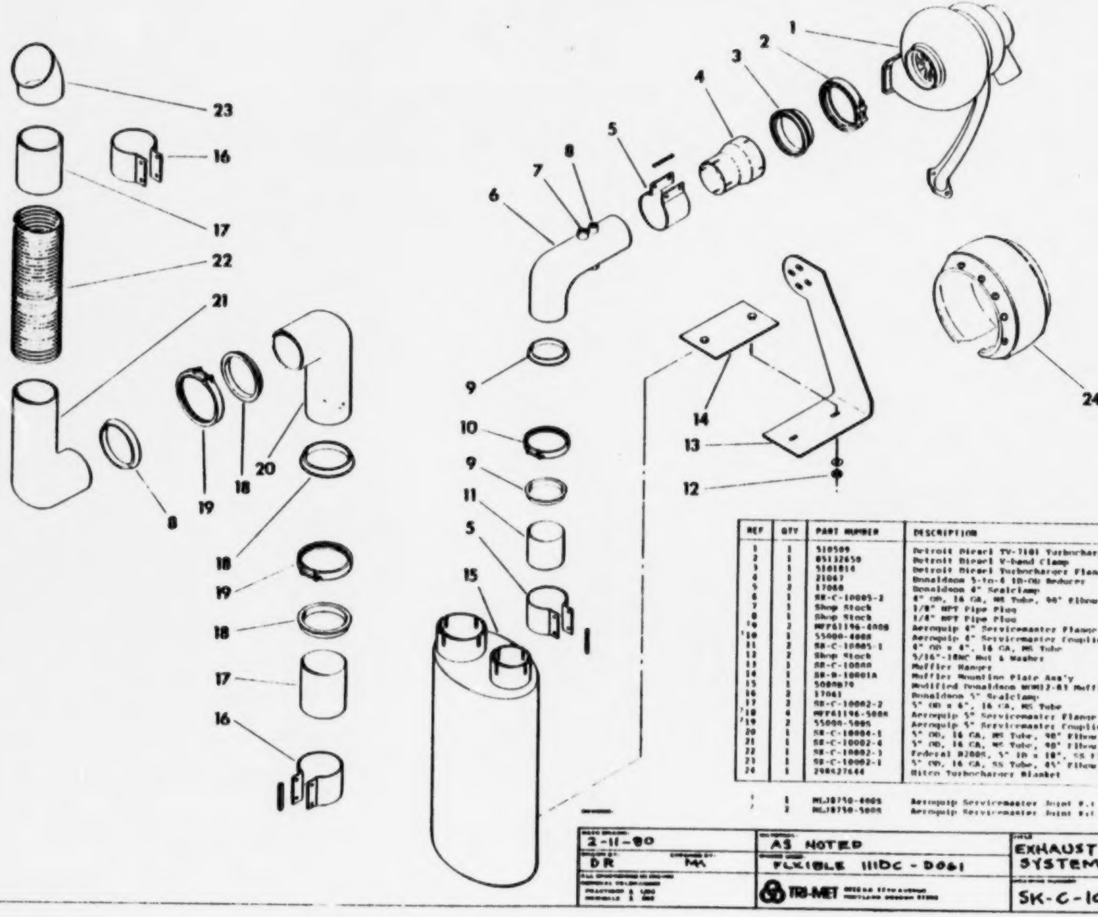
1-29-79	N/A	SNORKLE INSTALLATION
S.P.S.	FLXIBLE 111CC 0061	
	TRI-MET	SK-C-10024-A

SK-B-10025


REFER TO: SK-B-10023A
REBUILT GRILLE
$\frac{7}{16}$ X 1 SLOT
2 PLACES
$\frac{13}{32}$ DIA
2 HOLES
DRILL THRU AND TAP $\frac{1}{4}$-20 NC
TO FIT GRILLE
2 HOLES
BEND DOWN 90°
$\frac{3}{16}$ INSIDE RADIUS
2 R TYP
14
9
8
$3\frac{1}{2}$
$1\frac{3}{4}$
4
$2\frac{1}{2}$
$35\frac{1}{4}$
$\frac{1}{2}$
5
6
9
$3\frac{1}{2}$
$\frac{3}{4}$
4
$2\frac{1}{2}$

REVISED:

DATE DRAWN 1-3-80	MATERIAL 5/32 M. S. PLATE	TITLE GRILLE SUPPORT
DRAWN BY M.C. KAYE CHECKED BY: GPS	WHERE USED FLXIBLE 111DC-D061	
ALL DIMENSIONS IN INCHES GENERAL TOLERANCES FRACTIONS ± 1/64 DECIMALS ± .005	TRI-MET 4012 S.E. 17TH AVENUE PORTLAND, OREGON 97202	DRAWING NUMBER SK-B-10025



REF	QTY	PART NUMBER	DESCRIPTION
1	1	510509	Detroit Diesel TV-7101 Turbocharger
2	1	05132650	Detroit Diesel V-band Clamp
3	1	5101816	Detroit Diesel Turbocharger Flange
4	1	21067	Donaldson 5-to-4 ID-OD Reducer
5	2	17060	Donaldson 4" Sealclamp
6	1	SK-C-10005-2	4" OD, 16 GA, MS Tube, 90° Elbow Ass'y
7	1	Shop Stock	1/8" NPT Pipe Plug
8	1	Shop Stock	1/8" NPT Pipe Plug
[1] 9	2	MFF61196-4008	Aeroquip 4" Servicemaster Flange
[1] 10	1	55000-4008	Aeroquip 4" Servicemaster Coupling
11	2	SK-C-10005-1	4" OD x 4", 16 GA, MS Tube
12	2	Shop Stock	5/16"-18NC Nut & Washer
13	1	SK-C-10008	Muffler Hanger
14	1	SK-B-10001A	Muffler Mounting Plate Ass'y
15	1	5000070	Modified Donaldson MXM12-81 Muffler
16	2	17061	Donaldson 5" Sealclamp
17	2	SK-C-10002-2	5" OD x 6", 16 GA, MS Tube
[2] 18	4	MFF61196-5008	Aeroquip 5" Servicemaster Flange
[2] 19	2	55000-5008	Aeroquip 5" Servicemaster Coupling
20	1	SK-C-10004-1	5" OD, 16 GA, MS Tube, 90° Elbow
21	1	SK-C-10002-4	5" OD, 16 GA, MS Tube, 90° Elbow
22	1	SK-C-10002-3	Federal B2008, 5" ID x 18", SS Flex Tube
23	1	SK-C-10002-1	5" OD, 16 GA, SS Tube, 45° Elbow
24	1	2906327644	Hitco Turbocharger Blanket

[1] 1 MLJ8750-4008 Aeroquip Servicemaster Joint Kit - 4"
[2] 2 MLJ8750-5008 Aeroquip Servicemaster Joint Kit - 5"

2-11-80	AS NOTED	EXHAUST SYSTEM INST
DR MA	FLXIBLE 111DC - D061	
	TRI-MET	SK-C-10026A

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APPENDIX D

SUPPLEMENTAL INFORMATION ON RECENTLY COMPLETED RETROFIT TREATMENT OF GENERAL MOTORS BUSES

TABLE 1-D

RESULTS OF ACOUSTICAL RETROFIT TREATMENT OF GENERAL MOTORS AND FLXIBLE BUSES

			SOUND LEVELS (dBA)		
			BASELINE	TREATED	CHANGE
EXTERIOR	GM	FAN NORMAL	78	75	-3
		FAN ON	83	80	-3
	FLXIBLE	FAN NORMAL	79.5	75.5	-4
		FAN ON	81.5	79.5	-2
INTERIOR	GM	FAN NORMAL	75.5	71	-4.5
		FAN ON	79	75	-4
	FLXIBLE	FAN NORMAL	79.5	76.5	-3
		FAN ON	83.5	80.5	-3

APPENDIX E

GUIDANCE ON NOISE ABATEMENT RETROFITS TO UMTA GRANTEES

DEPARTMENT OF TRANSPORTATION
URBAN MASS TRANSPORTATION ADMINISTRATION
WASHINGTON, D.C. 20590

APR 18 1980

Dear UMTA Grantee:

On August 2, 1979, President Carter announced the Urban Noise Program. The policy statement directs Federal agencies to take steps to reduce urban noise. One of these actions is the promotion of the use of quiet-design features in the planning, design, and operation of proposed urban transportation projects. In keeping with the presidential directive, UMTA will consider the cost of any reasonable noise reduction features in addition to those required under Federal, State or local law as an eligible expense for an UMTA funded project.

These additional costs would include the expense of reasonable measures taken to reduce the level of construction noise at project sites and the installation of noise reduction features on new transit vehicles or vehicles undergoing major rehabilitation. Eligible expenses also include the cost of constructing or installing noise reduction features as part of a new or rehabilitated fixed guideway system.

At a minimum, all UMTA funded projects must comply with existing governmental restrictions on noise levels. The grantee's signature on the grant contract document assures compliance with all relevant laws, rules, and regulations including those noise abatement requirements in effect in the grantee's area of operations. It is, therefore, the responsibility of each grantee to become familiar with those restrictions relating to the noise levels of its operations and take the necessary measures to be in compliance.

Adequate provisions should be included in the project specifications to ensure that these requirements are met. The costs incurred for noise abatement features required by law as well as reasonable costs for noise reduction beyond the statutory minimum are eligible costs under UMTA funded projects.

Grantees should consult with their state and local government agencies for specific noise abatement policies in their area. For assistance with the development of the necessary project application, consult the UMTA office in your region.

Peter Benjamin

Peter Benjamin
Acting Associate Administrator
for Transit Assistance